MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLI. FEBRUARY 11, 1881. No. 4.

J. R. HIND, Esq., F.R.S., President, in the Chair.

W. H. St. Quintin Gage, Esq., Eastbourne;
O. Theodor Olsen, Esq., 40 Cleethorpe Road, Grimsby; and
James George Vine, Esq., Rosslyn House, Bromfelde Road, Clapham, S.W.;
were balloted for, and duly elected Fellows of the Society.

REPORT OF THE COUNCIL TO THE SIXTY-FIRST ANNUAL GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of the Society:—

	Compounders	Annual Subscribers	Non-resident	Mathematical Society	Total Fellows	Associates	Patron	Grand Total
December 31, 1879 ...	214	368	4	5	591	43	1	635
Since elected	+6	+20	...	...	...	...	...	...
Deceased	−2	−7	−1	...	...	−2	...	...
Removals	+3	−3	...	...	...	...	...	...
Resigned	−1	−4	...	...	...	...	...	...
Expelled	...	−11	...	...	...	...	...	...
December 31, 1880 ...	220	363	3	5	591	41	1	633

Mr. Barrow's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at Bankers', Dec. 31, 1879	217	7	0			
„ in hand of Secretary of Library Committee:						
On account of Turnor Fund	18	6	8			
„ Library Expenses ...	22	7	3			
				258	0	11
Dividend on £7,500 Consols	110	3	2			
„ £5,700 New 3 per cent. Stock ...	83	14	5			
„ £7,500 Consols	110	3	2			
„ £5,700 New 3 per cent. Stock ...	83	7	3			
				387	8	0
Received on account of Subscriptions:						
Arrears	173	5	0			
254 Contributions for 1880	533	8	0			
3 Contributions for 1881	6	6	0			
24 Admission Fees	50	8	0			
18 First Contributions	31	10	0			
				794	17	0
9 Composition Fees				189	0	0
Sales of Publications:						
At Society's Rooms, 1880	35	8	4			
At Williams & Norgate's, 1879	36	19	0			
				72	7	4
Due to Assistant Secretary on Petty Cash account, Dec. 31, 1880				5	4	0
				£1,706	17	3

Astronomical Society, from Dec. 31, 1879, *to Dec.* 31, 1880.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Salaries:						
Editor of *Monthly Notices*	60	0	0			
Assistant Secretary	225	0	0			
				285	0	0
Income Tax and House Duty				9	3	9
Fire Insurance				7	16	6
Printing: Spottiswoode & Co.	331	12	0			
Hazell, Watson, & Viney	326	4	10			
				657	16	10
Lithography and Engraving				9	10	0
Turnor Fund: Books purchased during year ...				30	12	2
Library Expenses: Binding	40	8	10			
Library Catalogue	45	0	0			
				85	8	10
House expenses	31	16	9			
Wages	31	14	0			
Stamps and postage	57	1	4			
Carriage of books and parcels	5	9	10			
Stationery and office expenses	13	12	2			
Expenses of meetings	20	0	0			
Coals and gas	57	10	6			
Fittings in hall and stock room	29	15	2			
Sundry fittings and repairs	8	1	3			
Whitewashing, papering, &c.	17	2	0			
Sundries	9	2	5			
				281	5	5
Mrs. Jackson-Gwilt's annuity				8	19	0
Due to Assistant Secretary on Petty Cash account, Jan. 1, 1880				1	4	5
Balance at Bankers', Dec. 31, 1880	317	14	10			
„ in hand of Assistant Secretary on account of Turnor Fund	12	5	6			
				330	0	4
				£1,706	17	3

Examined and found correct, Jan. 6, 1881.

J. Rand Capron,
A. M. W. Downing.

Assets and present property of the Society, January 1, 1881 :—

	£	s.	d.	£	s.	d.
Balance at Bankers', Dec. 31, 1880	317	14	10			
,, in hand of Assistant Secretary on account of Turnor Fund	12	5	6			
	330	0	4			
Less amount due to Assistant Secretary on Petty Cash account	5	4	0			
				324	16	4
Due on account of Subscriptions:						
1 Contribution of 4 years' standing ...	8	8	0			
14 ,, 3 ,, ...	88	4	0			
31 ,, 2 ,, ...	130	4	0			
49 ,, 1 ,, ...	102	18	0			
3 Admission Fees and First Contributions...	9	9	0			
Various amounts	8	8	0			
	347	11	0			
Less 3 Contributions paid in advance ...	6	6	0			
				341	5	0
Due for Publications	18	0	9			
,, from Williams & Norgate for sales during 1880	76	8	5			
				94	9	2

£7,500 Consols, including the Lee Fund (£300), the Turnor Fund (£450), and the Horrox Memorial Fund (£100).
£5,700 New 3 per cent. Stock, including Mrs. Jackson-Gwilt's gift (£300).
Astronomical and other MSS., Books, Prints, Instruments, &c.
Unsold Publications of the Society.
Five Gold Medals.

Report of the Auditors.

We, being two of the duly appointed Auditors, beg to lay before this General Meeting of the Royal Astronomical Society the following Report :—

1. We have examined the Treasurer's account, and an account of the assets and property of the Society, and have found and certified the same to be correct.

2. The receipts and expenditure for the past year are as stated in the Treasurer's account.

3. The cash in hand on December 31, 1880, including the balance at the bankers', amounted to 330*l.* 0*s.* 4*d.*

4. The funded property of the Society is the same as at the end of last year, and is in a satisfactory state.

5. We have laid on the table a list of the names of those Fellows who are now in arrear for sums due at the last Annual General Meeting, with the amount due against each Fellow's name.

J. Rand Capron,
A. M. W. Downing.

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	78	1	XXII.	35	...
II.	78	2	XXIII.	32	...
III.	...	...	XXIV.	24	...
IV.	...	...	XXV.	7	...
V.	...	...	XXVI.	11	...
VI.	44	1	XXVII.	3	...
VII.	2	...	XXVIII.	76	...
VIII.	142	2	XXIX.	54	1
IX.	24	3	XXX.	68	4
X.	150	2	XXXI.	99	2
XI.	186	2	XXXII.	122	4
XII.	12	2	XXXIII.	106	3
XIII.	152	3	XXXIV.	84	5
XIV.	110	3	XXXV.	70	1
XV.	129	2	XXXVI.	39	1
XVI.	110	1	XXXVII.	46	2
XVII.	137	1	XXXVIII.	107	5
XVIII.	167	...	XXXIX.	113	2
XIX.	67	...	XL.	126	6
XX.	31	...	Index to *Monthly Notices*	597	...
XXI.	20	...			

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to XL., no complete volumes can be formed from the separate numbers in stock.

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	7	...	XXIII.	157	1
I. Part 2	44	...	XXIV.	164	2
II. Part 1	57	...	XXV.	176	2
II. Part 2	23	...	XXVI.	180	2
III. Part 1	70	...	XXVII.	435	1
III. Part 2	89	...	XXVIII.	392	1
IV. Part 1	85	3	XXIX.	421	...
IV. Part 2	94	3	XXX.	170	...
V.	110	4	XXXI.	151	2
VI.	129	3	XXXII.	167	2
VII.	153	3	XXXIII.	173	1
VIII.	132	4	XXXIV.	172	7
IX.	140	4	XXXV.	119	4
X.	152	1	XXXVI. (with M.N.)	206	13
XI.	160	...	XXXVI. (without)	5	...
XII.	167	...	XXXVII. Part 1	357	8
XIII.	174	...	XXXVII. Part 2	305	6
XIV.	373	3	XXXVIII.	293	2
XV.	146	1	XXXIX. Part 1	266	4
XVI.	177	...	XXXIX. Part 2	275	5
XVII.	154	3	XL.	306	2
XVIII.	158	...	XLI.	493	5
XIX.	162	...	XLII.	271	6
XX.	161	2	XLIII.	297	3
XXI. Part 1	314	...	XLIV.	312	6
XXI. Part 2	99	...	XLV.	488	5
XXI. 1 & 2 (together)	67	1	Index to *Memoirs*	663	2
XXII.	162	1			

Instruments belonging to the Society.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.

No. 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Ultzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatoreal.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrant, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatoreal.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatoreal, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A quadrant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection :—

„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
„ 29. (3) $4\frac{6}{10}$-inch achromatic telescope, about 5 feet 6 inches focal length; finder; rack motion; double-image micrometer; two other micrometers; object-glass micrometer; one terrestrial and ten astronomical eyepieces, applied by means of two adapters, with equatoreal stand, clock movement.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
„ 33. (7) 2-foot navy telescope.
„ 34. (8) A transit instrument of 45 inches focal length; with iron stand, and also Ys for fixing to stone piers; two axis levels.
„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

No. 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch verticle circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle, by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.

No. 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton; a 10½-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane 2⅜-inch speculum, artificial horizon, and stand.
„ 59. (33) 2½-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough; the trough 8¼ by 4½ inches. Tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square: one beam compass.
„ 62. (36) A pentagraph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with the object-glass of rock crystal.
„ 70. Portable equatoreal stand.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. 9¼-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. A double image micrometer, by Troughton and Simms.

No. 86. A $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.

„ 87. A $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.

„ 88. A pendulum with 5-foot brass suspension rod, working on knife edges, by Thomas Jones.

„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.

„ 90. An Arabic celestial globe of bronze, not quite 6 inches in diameter.

„ 91. An astronomical time watchcase, by Professor Chevallier.

„ 92. A 2-foot protractor, with two moveable arms, and vernier.

„ 93. A beam compass, in box.

„ 94. A 2-foot navigation scale.

„ 95. Stand for testing measures of length.

„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position angles.

„ 97. A 12-cell Leclanché battery.

The following instruments have been presented to the Society by Mrs. Walter:—

No. 98. A 2 feet 6 inch navy telescope with object glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.

„ 99. A 12-inch transit instrument, by Fayrer & Son, with level and portable stand.

„ 100. A 9-inch transit instrument, with level and iron stand.

„ 101. A sun-dial, by G. Adams, London.

„ 102. A sun-dial, by Troughton.

„ 103. A sun-dial, by Casella.

„ 104. A sun-dial.

„ 105. A box sextant, by Troughton and Simms.

„ 106. An azimuth compass, by Schmalcalder, London.

„ 107. An azimuth compass, by C. Earle, Melbourne.

„ 108. An azimuth compass, by Negretti and Zambra.

„ 109. A dipleidoscope, by E. Dent.

„ 110. An Abney level, by Elliott.

„ 111. A pocket spectroscope, by Browning.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons:—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.

„ 12. The *Fuller* theodolite, to the Director of the Sydney Observatory.

No. 22. The *Matthew* equatoreal, to Mr. Brett.
„ 23. The *Matthew* transit, to Captain Noble.
„ 74. Registering spectroscope, with prism, to Mr. Lecky.
„ 76. One 5-prism spectroscope, to Mr. Plummer.
„ 78. The $9\frac{1}{4}$-inch reflector, to Mr. Neison.

From the *Sheepshanks* collection:—

No. 29. (3) Parallel wire micrometer, to the Rev. W. C. Bruce.
„ 30. (4) $3\frac{1}{4}$-inch equatoreal and stand, to Mr. Sadler.
„ 31. (5) $2\frac{3}{4}$-inch telescope and stand, to Mr. Birt.
„ 34. (8) Transit instrument, to the Rev. Professor Pritchard.
„ 35. (9) Repeating theodolite, to the Sydney Observatory.
69. (43) Telescope, with rock-crystal object-glass, to Dr. Huggins.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Professor Axel Möller, for his investigations of the motion of Faye's Comet. The President will lay before the Society the grounds upon which this award has been founded.

Publications of the Society.

Vol. XLV. of the *Memoirs* has been published during the past year. It contains the following papers:—

M. Souillart, 'Théorie analytique des mouvements des Satellites de Jupiter.'

W. H. M. Christie, 'On the Systematic Errors of the Greenwich North Polar Distances.'

Mr. Gill's Expedition for observing the Opposition of Mars.

Mr. Gill's account of his observations and reductions in connection with his expedition to Ascension to observe the Opposition of *Mars* in 1877 has been received by the Council, and the printing of it has been already commenced. It will appear in the *Memoirs*.

The Library.

During the year, the cataloguing has been steadily continued. About 6000 titles are now complete, and less than 3000 remain to be written. The library committee have drawn up a list of books, consisting of star atlases, works of reference, &c., which are not to be taken out of the library.

Schwabe's Sun-spot Observations.

In 1864, in response to a request from Dr. De la Rue and Prof. Balfour Stewart, Hofrath Schwabe allowed his valuable series of Sun-spot observations to be deposited in the Kew Observatory, and at the same time, in a letter printed in the *Monthly Notices*, vol. xxxvi. p. 298, desired that after his death they should be considered to be the property of this Society. These manuscripts have hitherto remained at Kew, where considerable use has been made of them in the reduction of the Kew solar photograms; but in the course of last year they have been transferred to the Society's library at the request of the Council.

The Transit of Venus, 1882.

At the request of the Treasury, a committee has been appointed by the Royal Society to advise the Government upon the steps which it is desirable to take in order to secure observations of the Transit of *Venus* across the Sun's disk 1882, December 6. The committee—which consists of the Astronomer Royal, the President of the Royal Society, the President of the Royal Astronomical Society, Professor J. C. Adams, the Earl of Crawford and Balcarres, Dr. De La Rue, Dr. Huggins, Professor H. J. S. Smith, Professor Stokes, and Mr. Stone—has already commenced its labours.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—C. Raganootha Chary.
Rev. R. S. Bower.
H. W. Buxton.
J. S. Eiffe.
William Gray.
W. A. Harris.
William Lassell.
Rev. R. C. Lumsden.
Captain J. Williams.

Associates:—Baron Dembowski.
Benjamin Peirce.
Prof. C. A. F. Peters.

Chintamanny Ragoonatha Chary, the head assistant in the Madras Observatory, died on February 5, 1880. He was attached to the Observatory for a period of nearly forty years, and served in succession in every grade under Captain Jacob and the present astronomer, Mr. Pogson. He contributed three papers to the *Monthly Notices*, viz.: 'On the Determination of Personal Equa-

tion by Observations of the Projected Image of the Sun" (vol. xix. p. 337); "Occultations visible in the month of August, 1868, at Madras and along the Shadow-Path of the Total Eclipse of the Sun in India" (vol. xxviii. p. 193); "On the Total Eclipse of the Sun, on December 11th, 1871, as visible in the Madras Presidency" (vol. xxxi. p. 137). He was elected a Fellow of the Society on January 12, 1872.

In 1874 he published a pamphlet on the Transit of Venus, being induced to do so, as he states, by the fact that "although the class of phenomena to which the Transit of Venus belongs is mentioned in Hindu treatises on Astronomy, especially of the Sidhanta Siromani, yet the Sidhantis or Hindu astronomers are really not familiar with the nature of this particular occurrence, and cannot predict it with even a rough approach to accuracy, happening as it does at such strange and rare intervals." The English edition is in the form of a dialogue, and the author mentions that he had been accustomed for so many years to discuss astronomical facts and methods verbally with Hindu professors of the art that his sketch naturally assumed this shape. It is stated in the preface that in the Sanscrit, Canarese, Malayalum, and Maharathi versions it was found convenient to vary this arrangement. The library of the Society contains, besides the English edition, copies of the version in Hindustani and Telugu. Among the list of subscribers to the pamphlet are the Government of Madras, 1,100 copies; of Bombay, 900; of the N.W. provinces, 300; the Chief Commissioner, Central Provinces, 200; the Maharajah Holkar, 240; Education Department, Bombay, 200; besides eleven subscribers for 100 or more copies, eight for forty or more, &c.

At the end of the pamphlet Mr. Chary printed an address delivered by him "at Pacheappah's Hall, Madras, on April 13, 1874, to a large meeting of native gentlemen." The object was to obtain support for a work upon Astronomy which should embody the corrections, equations and formulæ established by European research, "together with what is proper to retain from our own works, and thus to construct a manual accessible to Hindu astronomers, and sufficient for all the purposes to which Astronomy is applied in our social and religious practices." The title of this work was to be "Jyotisha Chintamani," and it was to consist of two volumes of about 500 and 300 pages respectively. Mr. Chary states that for five years he has devoted his leisure to this task, and that he intends to take eighteen months' furlough shortly, and to devote the whole of his energies to bringing the work to a conclusion. After explaining the cost of printing the book, and asking for assistance to enable him to undertake the publication, he proceeds: "It is a matter of the deepest regret that I should be unable to carry out my design, so long the cherished object of my life, without invoking help from others. But you are all aware that my income has always been very slight, barely sufficient to provide for simple wants; an allowance of Rs. 100 per mensem after thirty-

three years' service leaves scanty margin for saving, and what little I have managed to put aside has been dispersed in meeting the charges which have had to be incurred in proceeding with the work so far. My health, too, is becoming weaker daily, and I cannot shut my eyes to the fact that my retirement from active work is not very distant."

He also suggested that a native Observatory should be founded by voluntary effort, and offered to present his own instruments as a nucleus of such an institution; after referring to the importance of co-operation in science, he adds: "In Europe, excluding Russia, there now exist fifty-four public and ten private Observatories spread over an area of less than two million square miles. In India with a surface of one and a half million miles we have but one, and that one wholly supported by the State . . . I recommend no more than that a modest but thorough place of instruction and study should be founded where theoretical knowledge can be united to actual practical work, and where the mathematician equally with the humble Sidhanti may find pleasure and profit. Such places exist in hundreds in Europe, but nowhere is the need for them greater than in India. Not much money, a little zeal, a little stedfastness of purpose, wed these to a regard for science, and soon would the metropolis of Southern India be graced with an Institution which would be an honour to the country."

In an obituary notice of Mr. Chary which appeared in the *Madras Mail* for February 7, 1880, he is spoken of as an unassuming and distinguished native gentleman, and it is stated that his strict honesty and ready skill as an observer, combined with accuracy and speed in computation, and a fair and useful amount of self-acquired mathematical knowledge, rendered him, until disabled by impaired health, invaluable in the Observatory, and that the chief share in the catalogue of stars in hand, with the Transit Circle, since 1862, comprising already over 38,000 separate observations, is due to his personal exertions. The notice concludes as follows:—"He was twice successfully engaged in observations of total eclipses of the Sun: on the first occasion in August 1868, at Vunpurthy, in the Nizam's dominions, in independent charge of a branch expedition for the purpose; and on the second, in December 1871, at Avenasky, in the Coimbatore District. He was the first and only native of India who has yet entered the lists as a discoverer of new celestial objects, having detected two new variable stars, *R Reticuli*, in 1867, and *V Cephei*, in 1878. As editor of the astronomical portion of the Asylum Press Almanac, and of a native calendar published on his own responsibility, he has been before the public for the past twelve years; and he latterly took great interest in delivering public lectures on Astronomy, with a view to enlighten his countrymen upon the subject, and to convince them of the absurdity of their notions in regard to celestial phenomena, by familiar explanations, in simple terms, of the true principles of

the science, as opposed to the ignorant superstitions and rough predictions of Hindu astrologers and empirics of the old school." It is probable that his projected book was not published; there is no copy of any portion of it in the Society's library, and the writer of the notice in the *Madras Mail* does not refer to it.

James Sweetman Eiffe was the second son of Luke Eiffe, Esq., of Norman's Grove and Tirlstone, near Dublin, a gentleman of hunting celebrity in the past generation. He was born at his father's town residence in Rutland Square on December 25, 1804, and was intended for the army, an uncle offering him a commission; but a passion for horology overcoming every other consideration, he, soon after the completion of the full course of his collegiate education, and in opposition to the wishes of his family, directed his whole energies to the pursuit of his favourite science, and made everything subordinate to the one object of making the chronometer a perfect time-keeper. For his inventions for equalising the rates of chronometers in extremes of temperature, he received from the Government a reward, which, however, he only accepted as part payment of his claim. He also made various improvements in the astronomical clock. In 1842, an account of his improvements in chronometers was published by the Lords Commissioners of the Admiralty.

From a pecuniary point of view his efforts were unremunerative, and he exhausted his private resources and those of his wife in his experiments. He leaves a widow and an only son. He was elected a Fellow of this Society on April 8, 1842. He died at Ashford, Kent, on October 28, 1880.

John George Cockburn Curtis Godsman, whose death was announced in last year's Report, was born on April 6, 1817. When five years old he accompanied his father, an officer in the Royal Navy, on a voyage to India. He remained about two years at Madras, and then returned to England, and was educated at the Royal Naval School at Greenwich. At the age of thirteen he entered the Royal Navy as a volunteer of the first class, and sailed to Mauritius, whence he returned in about three years. At the age of seventeen he was appointed to H.M.S. *Sulphur* as midshipman, and the principal part of the ten subsequent years was spent by him at sea. Upon his return to England, having quitted the Royal Navy, he was, in conjunction with Captain Wolfe and Lieutenant Beechy, directed by the Admiralty to make a survey of the Cove of Cork. Upon the completion of this survey he entered the Hydrographer's office. In 1845 he was selected by the Admiralty for the discharge of important duties in connection with the Tidal Harbours Commission. From 1846 to 1849 he was employed by the local authorities as well as by the Admiralty to conduct investigations upon the tidal phe-

nomena of the Mersey, Nene, and Dee. In May 1849 he surveyed the lower portion of the river Nene, in connection with the Admiralty inquiry into the Norfolk Estuary Bill of that year; and in April 1850 he reported to the Admiralty on the proposed Hartlepool West Harbour and Docks.

In 1852 he was at New York engaged in the Croton Aqueduct department. He then went to Spain, and for a considerable time worked under the Spanish Government in the irrigation of the 'Patrimonia Reale.' In 1861, as Admiralty Inspector, he held an inquiry on the proposed Nene Valley Drainage and Navigation Works. In 1864, he went to Turkey, and was employed on the Smyrna and Casaba Railway. His last work was in 1868, when he was requested to report upon the utilisation of the fresh-water supply of the Thorney river, a tributary to the Nene.

In 1877 he had a slight attack of paralysis, from which, however, he quickly recovered. On December 4, 1879, he was stricken with apoplexy in Westminster, and died on the following day.

He was elected a Fellow of this Society on January 10, 1845; he was also a member of the Institute of Civil Engineers.

He was known for the greater part of his life as Mr. John George Cockburn Curtis, the name of Godsman having been assumed by him only in recent years.

Henry Parr Hamilton, whose death was announced in last year's Report, was the son of Alexander Hamilton, physician, Professor in the University of Edinburgh, and was descended from an elder branch of the ducal family of the same name. He was born on April 3, 1794, and was educated at the High School, Edinburgh, under Dugald Stewart. He thence proceeded to Trinity College, Cambridge, having been entered on the side of Mr. Young. In the Admission Book of the college, under date October 21, 1811, he gives his native place as Blandfield, Midlothian, and the name of his master as Dr. Baird. He entered the college as a pensioner and was elected scholar in 1814. He graduated as ninth wrangler, in 1816, Whewell being second wrangler, and Richard Sheepshanks tenth wrangler, in the same year. He was elected Fellow of Trinity in 1818, at the same time as Connop Thirlwall and J. C. Hare, and held various college offices from 1819 to 1830: viz., Sub-Lecturer (*i.e.* examiner in the college examinations), 1820, 1821, 1823, 1825; Latin Lecturer, 1824; Head Lecturer (*i.e.* chief examiner), 1830; Junior Dean, 1823–25, Senior Dean, 1825–30. In 1830 he was presented by the Marquis of Ailesbury to the rectory of Wath, near Ripon, where he remained until 1850, when he was appointed Dean of Salisbury, in succession to the Very Rev. Francis Lear. He died at Salisbury on Feb. 7, 1880, aged 86. For the last twenty years of his life his health was very weak, and he seldom appeared in public. The restoration of the Cathedral was, however, a subject of great interest with him to the last. He may be said to

have been the originator of this work, which was the object of his constant solicitude, and towards which he contributed many thousands of pounds. His kindness of heart and his liberality are widely known; and even in the University he is still remembered for the amiable and courteous manner in which he discharged his duties.

On October 24, 1833, he married Eleanor, eldest daughter of Thomas Mason, Esq., of Copt Hewick Hall, Ripon, who survives him. His only child, Katharine Jane, is married to Sir Edward Hulse, Bart.

In 1826 he published *The Principles of Analytical Geometry designed for the Use of Students in the University*, a book of 320 pp. 8vo., in the Advertisement to which he states that "the work was undertaken with a view of illustrating the importance of Analytical Geometry as a method of investigation," and that his principal end will have been attained if it "shall be the means of attracting the attention of the student to a branch of science which is of extensive utility in the higher departments of mathematics;" and in 1828 he published *An Analytical System of Conic Sections designed for the Use of Students in the University* (pp. 189). In the preface to the latter he explains that the design of the work is to facilitate the study of Conic Sections "upon principles adapted to the present state of mathematical science." Referring to the former work (in which the discussion of the general equation of the second degree preceded that of the parabola, ellipse, and hyperbola), he states that "subsequent experience has taught him that this method of treating Conic Sections, although sanctioned by the practice of very eminent writers on the Continent, is too scientific, if he may use the expression, for elementary instruction." This objection he meets by adopting the focus and directrix definition of the Conic Sections (for which, he states, he is indebted to Boscovich*), and by deducing from it and discussing in separate chapters the equations of the parabola, ellipse, and hyperbola referred to their axes. This work went through five editions: the second was published in 1830, the fourth in 1838, and the fifth in 1843.

There was also a German translation: *H. P. Hamilton's System der Kegelschnitte analytisch dargestellt. Aus dem Englischen übersetzt von J. H. Beuchendorff* (Berlin, 1828). The articles "Analytical Geometry" and "Conic Sections" in the first volume of the *Encyclopædia Metropolitana*, were written by Hamilton; the date of these articles is probably about 1826. He was also the author of the following pamphlets, chiefly relat-

* The property of the focus, directrix, and determining ratio was known to Pappus. It was first brought fully to light by Sir I. Newton, and used as a definition by Boscovich. It seems to have been first introduced into a Cambridge text-book on Conics by T. Newton, in 1794, in his *Short Treatise on the Conic Sections*: see C. Taylor's *Ancient and Modern Geometry of Conics* (1881), p. lxxi.

ing to education :—*The Education of the Lower Classes* (1841) ; *A Sermon at Ripon at the triennial Visitation of the Bishop of Ripon, September* 3, 1844 ; *Practical Remarks on Popular Education in England and Wales* (1847) ; *The Church and the Education Question* (1848, and, second edition, 1855) ; *The Privy Council and the National Society* (1850).

Hamilton's work was not the first English treatise on Analytical Geometry, as Lardner's *Algebraic Geometry* was published three years earlier, in 1823, but it was the first Cambridge book, and the first which included Solid Geometry. The first edition of Wood's *Algebra*, which appeared in 1795, contained, as Part IV., a chapter of 30 pages "On the Application of Algebra to Geometry," in which are given the equations of the straight line, ellipse, cissoid, conchoid, the construction of equations, &c. This chapter remained unaltered in the ninth edition (1830), and until the publication of Hamilton's book seems to have formed the only introduction to Analytical Geometry existing in the University. The Senate House papers from 1800 to 1820 show that at the beginning of the century Analytical Geometry was always represented to some extent, though scarcely as an independent subject, most of the questions relating to areas, loci, &c., in which but little more than the mode of representation by means of ordinates and abscissæ was involved. In 1833, Peacock published (anonymously) his *Syllabus of Trigonometry, and the Application of Algebra to Geometry*, seventy pages of which are devoted to Analytical Geometry; there was a second edition in 1836. Hymers's *Conic Sections* appeared in 1837 ; it superseded Hamilton's in the University, and remained the standard work until the publication of Salmon's, Todhunter's, and other textbooks still in use. Hamilton's work, however, was used in schools for years after it had been replaced by Hymers's in the University. Hymers's *Analytical Geometry of Three Dimensions* was published in 1830. The other early English books on Analytical Geometry are *The Elements of Curves* (Anon., Oxford, 1828) and the treatises of Young (1830), Waud (1835), and Wright (1836).

It will thus be seen that the publication of Hamilton's works is of historic importance in connection with the studies of the University, and that they helped onward the great movement started by Herschel, Peacock, and Babbage, for the reform of English mathematics, which at length succeeded in placing Cambridge students in an equal position with those of other European countries. The history of the introduction of the Differential Calculus into the University in place of the Newtonian method of Fluxions is well known and need not be referred to further here ; a short account will be found in the biographical notice of Peacock published in the *Monthly Notices*, vol. xix. pp. 125–128 (1859). One sentence from this account may, however, be quoted. Referring to Peacock's Syllabus of Trigonometry and Analytical Geometry, it is remarked that, "the reformers had kept their

eye too exclusively upon the Differential Calculus, of which this publication was a kind of confession." This seems to be true, and it is to be observed that, although great interest has been displayed in the history of the introduction of the Differential Calculus into the Cambridge examinations, but little attention has been devoted to the gradual growth of Analytical Geometry as a separate subject, which was taking place at about the same time. It is interesting to remark that the reasons which induced Hamilton to recur to the focus and directrix property as a definition still hold good; and that, although there is no doubt that, in a scientific development of the subject, the discussion of the general equation of the second degree should precede that of the particular cases, the subject is rendered much easier for the beginner if the parabola, ellipse, and hyperbola are considered separately immediately after the circle; and the method adopted by Hamilton in his *Conic Sections* has been generally followed in the multitude of text-books which have been published in recent years.

The Royal Astronomical Society had its origin in a meeting of fourteen gentlemen at Freemasons' Tavern on January 12, 1820, and was formally founded on February 8, 1820. Only two months later, on April 14, Hamilton was elected a Fellow, and at the time of his death he was the oldest Fellow of the Society. He thus connected the present time, not only with the revival of mathematics in England, but also with the foundation of the Society. Nearly all his contemporaries who were engaged in similar work near the beginning of the century, Herschel, Peacock, Babbage, Whewell, De Morgan, have passed away and their share in the movement has already been recorded in the pages of the *Monthly Notices*. It may be remarked, however, that the Society still numbers among its Fellows Mr. J. C. Ebden, who was sixth wrangler in Hamilton's year (1816), and was elected a Fellow of the Society only two months later than Hamilton, on June 9, 1820. Hamilton was elected a Fellow of the Royal Society on January 17, 1828; he was also a Fellow of the Royal Society of Edinburgh, and of the Geological Society.

J. W. L. G.

William Augustus Harris was born at Bovey Tracey, in Devonshire, and was educated at Blundell's School, Tiverton. He obtained a Scholarship at Balliol College, Oxford, and was placed in the second class in the Final Examination in Law and Modern History. In 1869 he was called to the English bar, and in 1870 to the American bar. His constant trips to the United States in the years 1871–1877 greatly impaired his health, which completely broke down in 1878. He spent the earlier part of the winter of that year at Davos, and then proceeded to San Remo, whence he returned to England in May 1879 rather worse than better for his residence abroad. In the February following

he died of consumption at the early age of 33, in the midst of a promising career.

He was the author of several books, the last of which—*Harris's Mining Laws*, published in 1877—is a work of much use to the profession.

He was elected a Fellow of this Society on February 11, 1870, and was a member of the Eclipse Expedition to Sicily in that year.

William Lassell died at Maidenhead, October 5, 1880, aged 81 years. He was born at Bolton, Lancashire, June 18, 1799. He acquired the rudiments of education at a day school in his native town, during which period his father died, and he thence went for eighteen months to an academy at Rochdale.

In 1814 he entered a merchant's office at Liverpool, and there served a seven years' apprenticeship. He commenced business in Liverpool as a brewer about the year 1825, without, however, much taste or inclination for trade, and spent almost all his leisure time in his favourite pursuit of astronomy and the mechanics connected therewith.

Mr. Lassell possessed a great love and aptitude for mechanical invention, and for this reason "he belonged," to use the words of Sir John Herschel, "to that class of observers who have created their own instrumental means, who have felt their own wants, and supplied them in their own way." The qualities which enabled Mr. Lassell to do all this made him what he was. The work was the revelation of the man. He felt precisely where lay the difficulties and wants which met him in his work, because he was sensitive and sympathetic. He could deal successfully with these difficulties and supply these wants often in a masterly and original way, because he could think for himself cautiously yet boldly. He could work out his conceptions in new and difficult directions to a successful issue, because the constancy of his character showed itself here in concentration of thought and perseverance of action. These qualities, sensitive sympathy, wise prudence, constancy, were those which pre-eminently characterised him as a man and made him to those who knew him a friend of rare worth.

In the history of science Mr. Lassell's name will rank with those of Herschel and the late Lord Rosse in connection with that essentially British instrument, the reflecting telescope, whether we consider the genius and perseverance displayed in the construction of these instruments, or the important discoveries which have resulted from their use. About 1820 Mr. Lassell, then in his twenty-first year, began to construct reflecting telescopes for himself. It is perhaps to circumstances which he at the time considered unfavourable that science is indebted for much that Mr. Lassell has accomplished. At that time he did not possess sufficient means to enable him to purchase expensive instruments, and besides "his business avocations were such as

most men consider of an engrossing nature." The value to him in his subsequent work of the energy and power of resource which were in this way so strongly developed in his character at an early age, it is difficult rightly to appraise. His success with the first two instruments, which he attempted simultaneously (a Newtonian of seven inches' diameter and a Gregorian of the same size), encouraged him to make a Newtonian of nine inches' aperture. The instrument, which was erected in an Observatory at his residence near Liverpool, happily named Starfield, may be said to form an epoch in the history of the reflecting telescope, in consequence of the successful way in which Mr. Lassell, on a plan of his own, secured to it the inestimable advantages of the equatoreal movement. The several mirrors made for this instrument were of great excellence. The Observatory note-books of the late Mr. Dawes, which are in the writer's possession, bear record to the delicate tests for figure to which these mirrors were put on the occasion of the frequent visits of Mr. Dawes to his friend's Observatory. With this instrument Mr. Lassell worked diligently, and detected, without knowledge of its existence, the sixth star in the trapezium of the Nebula of *Orion*. This instrument is fully described in the twelfth volume of the *Memoirs* of the Royal Astronomical Society.

About the year 1844 Mr. Lassell conceived the bold idea of constructing a reflector of two feet aperture and twenty feet local length, to be mounted equatoreally on the same principle. He spared neither pains nor cost to make this instrument as perfect as possible, both optically and mechanically. As a preliminary step he visited the late Earl of Rosse at Birr Castle, and commenced the specula for the new instrument upon a machine similar in construction to that employed by that nobleman. After some months' work he was not satisfied with this apparatus, and was led in consequence to contrive a machine for imitating as closely as possible those motions of the hand by which he had been accustomed to produce perfect surfaces on smaller specula. "The essential difference of these constructions," to use the words of Sir George Airy, "as regards the movements of the grinder, is this: that in Lord Rosse's apparatus every stroke is very nearly straight, while in Mr. Lassell's apparatus there is no resemblance to a straight movement at any part of the stroke." This is not the place to describe the many new contrivances in the mode of support of the mirror, in the equatoreal mounting, in the polishing machine, and in the arrangements of the dome under which it was erected, which enabled Mr. Lassell to bring his telescope to a high degree of perfection. In this connection it should be noticed, to use Sir John Herschel's words, "that in Mr. Nasmyth he was fortunate to find a mechanist capable of executing in the highest perfection all his conceptions, and prepared by his own love of astronomy and practical acquaintance with astronomical observations, and with the construction of specula, to give them their full effect."

With this fine instrument he discovered the satellite of *Neptune*. This minute body was seen on October 10, 1846, but it was not until the next year that it could be satisfactorily followed and its existence fully confirmed. The superiority of the telescope and the vigilance and skill of the observer were further shown by the discovery in 1848, simultaneously with Professor Bond in America, of an eighth satellite of *Saturn*, of extreme minuteness, which was named *Hyperion*. In 1851, after long and careful search, he established the existence of two additional satellites of the planet *Uranus* (*Umbriel* and *Ariel*), interior to the two discovered by Sir William Herschel in 1787.

In the autumn of 1852 he took this twenty-foot telescope to Malta, and observed with it there through the winter. A very careful and detailed drawing of the Nebula of *Orion*, and drawings of several planetary nebulæ made at Malta, will be found in vol. xxxiii. of the *Memoirs* of the Royal Astronomical Society. With respect to the planets, his discoveries, to use his own words, "were rather negative than otherwise," for he was satisfied, that without great increase of optical power, no other satellite of *Neptune* could be detected. With regard to *Uranus* he says: "I am fully persuaded that either he has no other satellite than the four, or, if he has, they remain yet to be discovered."

Mr. Lassell's energy and zeal in the cause of science did not permit him to remain content with this magnificent telescope. His last work was a much larger telescope—four feet in aperture and thirty-seven feet focus, mounted equatoreally, which was erected at Malta in 1861. The work done with it in the next three years, during the last two of which he was assisted by Mr. Marth, is described, as well as the instrument itself, in vol. xxxvi. of the *Memoirs* of the Royal Astronomical Society. This work consists of numerous observations of nebulæ and satellites, and a catalogue of the places of 600 new nebulæ discovered at Malta. It is not possible to suppress a feeling of regret that this grand instrument no longer exists.

Mr. Lassell was very successful in the great brilliancy and permanence of polish in his mirrors. Within the last few years the writer has been shown specula by Mr. Lassell, which had been polished for more than twenty years, and which appeared as bright as if but just removed from the polishing machine. His earlier metal differed from that employed by Lord Rosse, in that it contained a small quantity of arsenic in addition to copper and tin. In the case of his four-foot mirrors the arsenic was omitted. He seems to have considered that the perfection of the metal depended upon the accurate relative proportion of the copper to the tin, and that in consequence of the uncertainty of the state of purity of the metals, this proportion would be obtained with the necessary accuracy only by a series of testings, while the metal was in the pot.

After his return from Malta, Mr. Lassell purchased a residence near Maidenhead, and erected there in an Observatory his

equatoreal telescope of two-foot aperture. Mr. Lassell's experience in re-polishing his four-foot mirror suggested to him some alterations in his polishing machine. After his return he was able to carry out experiments in connection with the suggested alterations in a workshop erected at Maidenhead, and succeeded in constructing an improved form of polishing machine, which is described in the *Philosophical Transactions* for 1874. The numerous papers by Mr. Lassell, to be found in the *Monthly Notices* and the *Memoirs* of the Royal Astronomical Society, bear abundant record to his industry and skill, and make us feel that in Mr. Lassell's death we have to deplore the loss of one who contributed largely to the advancement of the science of his age.

He was elected a Fellow of this Society on June 14, 1839, and received the Gold Medal in 1849 "for the construction of his Equatoreal Instrument and for the discoveries made with it;" the address, in presenting the medal, being delivered by the President, Sir J. F. W. Herschel. He was elected President of the Society in 1870, and, as usual, held the office for two years. He was for many years a member of the Council, and was a most regular attendant at its meetings up to his death.

He was elected a Fellow of the Royal Society in 1849, and received one of the Royal Medals in 1858. Among other honours bestowed upon him, may be mentioned the honorary degree of LL.D. conferred upon him by the University of Cambridge, and the honorary membership of the Royal Societies of Edinburgh and Upsala. W. H.

Rev. Robert Comyn Lumsden was born at Dalkeith, and studied at the University of Edinburgh. He was elected a Fellow of the Royal Geographical Society in 1860, and of this Society on May 10, 1861. He died of apoplexy, after a few hours' illness, on October 25, 1880, aged 56.

Benjamin Peirce was born at Salem, Massachusetts, on April 4, 1809. He was the son of Benjamin Peirce, the librarian of Harvard, who died in 1831, and is well known in connection with his posthumous History of that University. He graduated at Harvard in 1829, and was made Tutor in 1831 and Professor in 1833. In 1842 he was appointed Perkins Professor of Astronomy and Mathematics in the University, and occupied this Chair until his death. He also held the offices of Consulting Astronomer of the American Ephemeris and Nautical Almanac from 1853 to 1867, and Superintendent of the United States Coast Survey from 1867 to 1874. From 1874 to his death he was Consulting Geometer of the Coast Survey. He died at his house at Cambridge, Mass., on October 6, 1880, after an illness of about three months.

The proof sheets of Bowditch's translation of Laplace's *Mécanique Céleste* were read by Peirce. On p. 61 of the Memoir

of Bowditch, prefixed to the fourth volume (1839) of this elaborate work, it is stated that Peirce's "revision of the entire work, when in the process of publication, and vigilance in detecting typographical errors, Dr. Bowditch always valued as an additional means of ensuring its accuracy;" and on p. 140, "Whenever one hundred and twenty pages were printed, Dr. Bowditch had them bound in a pamphlet form, and sent them to Professor Peirce, who in this manner read the work for the first time. He returned the pages with the list of errata, which were then corrected with a pen or otherwise in every copy of the whole edition." The Royal Society's Catalogue of Scientific Papers contains the titles of fifty-nine papers by Peirce, the earliest of which appeared in the *Mathematical Miscellany* for 1838, and related to Fox Talbot's researches upon the Integral Calculus. Many of his papers were published in *Gould's Astronomical Journal* and in the *Proceedings of the American Academy of Boston*. In 1842 the first number appeared of the *Cambridge Miscellany of Mathematics, Physics and Astronomy*, edited by Benjamin Peirce and James Lovering; but only four quarterly numbers were issued. It chiefly contained solutions of problems. About 1845 he published text-books on Trigonometry, Geometry and the Differential Calculus; but his largest work of this kind was his *Analytic Mechanics*, which appeared in 1855, and was dedicated to the memory of "my master in science, Nathaniel Bowditch, the father of American Geometry." The *Mechanics* is a beautifully printed quarto volume, and covers a wide range of subjects; but the mathematics is somewhat embarrassed by the notations employed. The list of subscribers to this work shows the general estimation in which Peirce was held by his countrymen at that time. In 1853 Peirce's *Tables of the Moon* were published. These were described at length in the *Monthly Notices*, vol. xiv. pp. 26–32 (1853). Peirce was the author of memoirs upon the Saturnian system, the lunar theory, the discovery of Neptune, the rejection of doubtful observations in the Method of Least Squares, &c.; and he also published a treatise entitled *Curves, Functions and Forces*. One of the best known of his more recent writings is his *Linear Associative Algebra* (Washington, 1870), an account of which was given by Spottiswoode in vol. iv. p. 152 of the *Proceedings of the London Mathematical Society*. He was one of the founders of the American National Academy of Sciences. In 1853 he presided over the American Association for the Advancement of Science. He was elected an Associate of this Society on April 12, 1850, and a Foreign Member of the Royal Society in 1852. He received the degree of LL.D. in 1847 from the University of North Carolina, and in 1867 from Harvard University.

He leaves a widow, three sons and a daughter. Two of his sons, J. M. Peirce and C. S. Peirce, are well known in science. The former is Professor of Mathematics in Harvard University, and the latter is the author of investigations upon the applica-

tion of algebra to logic, and of photometric researches which were referred to in the Annual Report for 1879 (*Monthly Notices*, xxxix. p. 270).

Christian Friedrich August Peters was born at Hamburg on September 7, 1806. His father was a merchant, who early remarked the ability of the boy for mathematical studies, and did his utmost to procure the necessary books for him. He attracted the attention of H. C. Schumacher, the director of the Observatory at Altona, who employed young Peters in computing ephemerides for his "Hülfstafeln," and for miscellaneous geodetical work. From the year 1826 Peters was employed under Schumacher's direction in the survey of the territory round Hamburg. Commencing with the same year, we find communications from him in the *Astronomische Nachrichten*, principally containing computations of orbits of comets and of occultations of stars.

Peters took his degree at Königsberg, under the illustrious Bessel; his dissertation bears the title, *Disquisitio de Motu Penduli in Aëre resistente.*

In the year 1834 he was appointed assistant at the Hamburg Observatory, the director being Ch. Rümker, who charged him with the observations with Repsold's Transit. Very few of the observations made by him with this excellent instrument are published.

A few years later W. Struve proposed him as one of the assistants to the director of the Pulkowa Observatory, then about to be finished. The Academy of St. Petersburg elected him to this office on December 15, 1838. He left his employment at Hamburg on October 1, 1839, and entered on October 11 upon his new duties at Pulkowa, where he immediately displayed great activity, jointly with his colleagues, Fuss, Sabler, and O. Struve, under the direction of W. Struve.

In recognition of his eminent services he was elected on February 5, 1842, an associate to the Academy of Sciences at St. Petersburg, and afterwards, on March 6, 1847, he was promoted to the rank of an extraordinary member.

His scientific papers written at that time and published in the volumes of the Academy, the *Recueil des Mémoires des Astronomes de Poulkova*, and the *Astronomische Nachrichten*, directed the attention of the scientific world to the eminent astronomer. He was elected an Associate of this Society on May 12, 1848, and received on February 13, 1852, the gold medal, the president, Professor J. C. Adams, delivering the address upon the occasion.

In the autumn of 1849 Peters returned to Germany, having left the Russian service. He was appointed Professor of Astronomy at the Königsberg University, and had besides secured the right to make use of the celebrated Heliometer of the Observatory. He did not, however, make many observations with this instrument. In his lectures at the University he had among his

pupils Radau and Marth. At Königsberg he wrote the memoir *Ueber die eigene Bewegung des Sirius*, and deduced therein the first orbit for the companion of this star, confirming entirely the views of Bessel, which had been opposed by W. Struve.

About this time Leverrier announced very sensible corrections to the positions of the fundamental stars as deduced from Bradley's observations by Bessel. The question being proposed for decision by the Dantzic Society, Peters obtained the prize by his memoir, *Die Abweichung des Greenwicher Passageninstruments in der Zeit von Sept.* 2, 1750, *bis Juli* 16, 1762.

In February 1854 Petersen, the director of the Observatory at Altona, who jointly with Professor Hansen of Gotha had after the decease of Schumacher edited the *Astronomische Nachrichten*, died. Peters was, after some months, appointed director of the Observatory and editor of the *Astronomische Nachrichten* by the Danish Government. He went to Altona in the autumn of 1854.

The first volume of the *Astronomische Nachrichten* edited by him is vol. xl., the last, vol. xcvi.

At Altona he commenced as early as 1855 to finish the reductions of Schumacher's geodetical works; for these computations he engaged in the autumn of 1855 Pape, afterwards his son-in-law. Instigated by this young and ardent astronomer, a new periodical was commenced by Peters under the title *Zeitschrift für populäre Mittheilungen*. After Pape's untimely death in 1862, it ceased to appear, three volumes having been issued.

The time of Peters was, in the last twenty years of his life, engrossed by many geodetical operations; the difference of longitude by means of the electric telegraph was determined under his direction between Altona and Schwerin, Altona and Kiel, Altona and Copenhagen, and Altona and Göttingen. He took also an active part in the yearly sessions of the International Committee for the European Triangulation, as the colleague of General Bayer.

After the termination of the Danish dominion in the German Elb-Duchies, the removal of the Observatory from Altona to Kiel, and its relation to the University, were duly considered. A new Observatory, near Kiel, was built after Peters' plan, and he commenced to reside there in 1872. Two years afterwards he was nominated Professor in the University. The new Observatory was partly equipped with the old instruments from Altona; but some new ones were procured. It is to be regretted that no description of them is published in books generally accessible to astronomers. It is only occasionally that observations made at this beautifully situated Observatory are now published.

Peters died on May 8, 1880, after a severe illness during the winter, leaving a widow, a son, assistant to his father in the Observatory, and a daughter, the widow of Dr. Pape. Several other children died long before him.

Proceedings of Observatories.

The following Reports of the proceedings of Observatories during the past year have been received by the Council from the Directors of the several Observatories:—

Royal Observatory, Greenwich.

The regular observations of the Sun, Moon, planets, and selected stars with the Transit Circle, and of the Moon with the Altazimuth, have been continued in the past year. A large number of phenomena of *Jupiter's* satellites, and 14 occultations of stars by the Moon have been observed, and the results have been communicated to the Society. In addition to observations of the beginning and ending of the Solar Eclipse of 1880, December 31, by several observers, a complete series of measures of differences of R.A. and N.P.D. of cusps and limbs of the Sun and Moon, was made during the eclipse with the S.E. Equatoreal. The measures were arranged in five sets, so as to give corrections to the tabular R.A. and N.P.D. of the Moon and to the adopted semi-diameters of Sun and Moon, and from 10 to 14 double observations of R.A. and N.P.D. were made in each set. These measures may be expected to give a very accurate determination of the Moon's place at an important part of her orbit.

Four determinations of the flexure of the Transit-Circle telescope, made during the past year under widely different conditions of temperature, confirm the change of sign remarked in 1879. The values found are $+0''{\cdot}19$, $+0''{\cdot}04$, $+0''{\cdot}04$, and $+0''{\cdot}20$. No correction for flexure has been applied since the beginning of 1879.

The horizontal circle of the Altazimuth has been re-graduated by Mr. Simms, the divisions having been nearly obliterated by repeated cleaning in the course of thirty years, and the division-errors have been determined for every 5°. To assist in the determination of zero of azimuth, a mark, consisting of a vertical slit illuminated by a reflector, has been fixed on the parapet of the Royal Naval College at a distance of about 1700 feet. This mark is now observed daily for azimuth-zero and error of collimation.

The spectroscopic observations have been made, as usual, with the Half-prism Spectroscope mounted on the S.E. Equatoreal. The chromosphere was examined on 39 days in 1880, prominences being seen on 38 of these days. On 9 days a more detailed examination of the spectrum of the chromosphere was made, the height, breadth, and relative brightness of all the chromospheric lines being recorded at every 15° round the Sun's limb.

Much attention has been given to the spectra of Sun-spots, and charts have been prepared showing, on 14 days of observation in 1880, the extent to which each of the lines in Ångström's maps between D and F is thickened over spots. The measures of displacement of the F or *b* lines in star spectra have been continued, and 81 stars have been observed during the year 1880, 28 of which had not been previously examined. Up to the end of 1880, the motions of 90 stars in the line of sight had been determined at Greenwich. All the spectroscopic observations have been completely reduced, and the copy for press has been prepared.

Photographs of the Sun have been taken on 160 days in 1880; on 23 there were no spots, and on 8 neither spots nor faculæ. As regards both spots and faculæ, a large increase is shown since 1879, accompanied by an increase in the mean distance from the Sun's equator. The photographs have been measured in duplicate up to the end of 1880, and the measures have been completely reduced and prepared for the printer.

A great advance has been made in the printing of the *Greenwich Observations* since the last Report. The volume for 1878 was printed and distributed last autumn, and the whole of the volume for 1879 has been sent for press. A large portion of the MS. for 1880 is in the printer's hands, and some proof-sheets have been received.

The delay in the appointment of an assistant to fill up the vacancy caused by Mr. Lynn's retirement in January 1881 has seriously crippled the Observatory; and though by an increase in the staff of computers the routine work has been kept up, there has been a great difficulty in supplying that critical examination on which the value of the results largely depends. Mr. Thomas Lewis has been recently appointed 2nd Class Assistant, the post having been vacant for exactly twelve months.

Cambridge Observatory.

Generally speaking the work has been of the same character as for several preceding years. The astronomical observations have been made mainly with the Transit Circle, and confined in great part to the zone lying between 25° and 30° of North Declination.

Of the Stars in this zone 2835 meridian observations have been made during the year, each of them determining both Right Ascension and Declination. For Clock Correction 620 observations of standard stars have been made, the West circle being read off at each observation, as the polar point for the zone stars has to be determined from these. In practice, for each zone, at least five standard stars, if possible, are observed.

For position of the instrument, *Polaris* has been observed 89 times above the Pole and 90 times below. The Circle is usually

read off several times at each observation, so that the 179 observations really include 454 circle readings, and, as we required a re-determination of the intervals of the Right Ascension wires, *Polaris* has been observed at all the wires when the weather has been favourable. The Nadir point is always observed at the close of each night's zone work, and at other times when it is judged necessary. It has been taken 174 times. There are 207 observations for collimation, and 173 for level. The observations for Nadir point and level are facilitated and rendered much more secure by an alteration in the mode of illuminating the wires through the Bohnenberger eye-piece. This was formerly done by means of a small lamp placed on a stand near to the eyepiece: it is now done by a much stronger light placed in the focus of a large lens at a distance of about 10 feet from the eye-piece. The improvement in the distinctness of the images is very striking, and the risk of heating the instrument much diminished.

A persistent effort was made to leave no zone star unobserved. This could have been effected probably before the close of the year had the unobserved stars been more uniformly distributed; as it is, there are still 723 stars in this class, and if the original determination to have at least three distinct observations of each star be carried out, 4742 observations will still be required in order to complete the zones.

The Reductions progress as rapidly as our resources will allow. The means are taken, and the correction for runs of microscopes applied to the end of 1880, and corrections for micrometer readings are calculated up to November 20. The Nadir points and corrections for level and collimation are calculated up to May 20. A large number of observations of *Polaris* are tabulated for the determination of intervals of R.A. wires, but, from the pressure of other work the final results have not yet been obtained. The true Right Ascensions and true North Polar Distances of the zone stars are calculated up to the end of 1878, and the calculations requisite to form the tables for reducing apparent place to mean are performed up to near the end of 1876.

The Northumberland equatoreal has been used in the occasional examination of planets and double stars, in the search for intra-mercurial planets and Faye's Comet, and in the observation of the Solar Eclipse of December 31.

The meteorological observations are regularly taken, and communicated every morning, by telegraph, to the Meteorological Office in London.

Dunsink Observatory.

In the last Annual Report it was mentioned that a series of observations of the Annual Parallax of 61 (B) *Cygni* had been completed. These have now been reduced and give for the

parallax $+0''\cdot4676 \pm 0''\cdot0321$. The comparison star is B.D.+38°, 4351.

A second series of observations of true position and distance of B.D.+50°, 1724 from Groombridge 1618, which was commenced on August 14, 1879, was concluded on July 29, 1880. Observations were made on 40 nights. The parallax concluded from the observations of distance in this series is $+0''\cdot3196 \pm\cdot052$. The former series has also been reduced in the past year, and the resulting parallax from distance is $+0''\cdot3472 \pm\cdot05$. The observations of position-angle must receive further consideration.

The parallax series for P. III. 242, commenced on January 11, 1879, was concluded on January 9, 1880. Observations were obtained on 29 nights. The result of the series is $\pi = -0''\cdot045 \pm 0\cdot070$. (See *Monthly Notices*, November 1880.)

A parallax series for the red star 249 (*a*) of Schjellerup's list (B.D.+34°, 4500) was commenced on November 25, 1876, and concluded on October 20, 1880. Observations of the distance and position of two comparison stars were obtained on 20 nights. The reductions have not yet been completed.

A parallax series for μ *Cephei* was commenced on August 19, 1880, with two comparison stars. This series is at present in progress. A series for Σ 2486 was commenced on October 3, 1880.

Observations of the following objects have been completed within the past year by the method given in "Dunsink Observations," Part iii. The results show that probably all these objects are more distant than 61 *Cygni*:

Schj. (Red) 83; *Schj.* (Red) 87; B.D.+19°, 2526; B.D.+35°, 2462; *S. Delphini*; B.D. +64°, 1713; B.D. + 65°, 1814; *Schj.* (Red) 269; σ *Cassiop.*; *Arg.* 49; *Arg.* 61; *Schj.* (Red) 1; *Schj.* (Red) 6; B.D. +52°, 262; *Schj.* (Red) 7 *a*; *Schj.* (Red) 20 (*a*); B.D. +47°, 779; *Oeltz. Arg.* 4090; *Schj.* (Red) 31; *Schj.* (Red) 41; ζ *Aurigæ*; *Schj.* (Red) 56 (*a*); *Schj.* (Red) 191 (*a*); B.D.+38°, 3362; B.D. +24°, 3914; B.D. +22°, 4203; B.D. +36°, 4028; B.D. +40°, 4141; 47 *Cygni*; B.D. +32°, 3980; *Schj.* (Red) 264 (*a*); *Schj.* (Red) 267; π *Andromedæ*; 56 *Andromedæ*; Σ 3042; ψ *Andromedæ*; 14 *Aurigæ*; 16 *Aurigæ*; B.D. +31°, 1111; Σ 872; Σ 644; B.D. +31°, 2962; B.D. +52°, 2058; B.D. +48°, 3133; B.D. +40°, 4373; B.D. +43°, 4375; μ^1 *Boötis*; 44 *Boötis*; P *II.* 72; ψ *Cassiop.*; P *XXIII.*, 101, 100; Σ 163; *Schj.* (Red) 241; B.D. +43°, 3422; Σ 477; Σ 865; Σ 866; Σ 876; Σ 878; Σ 884; Σ 896; Σ 905; Σ 904; Σ 916; Σ 918; Σ 928; Σ 922; Σ 3115; ϕ *Cassiop.*; ζ *Coronæ*; η *Coronæ*; o^2 *Cygni*; χ^1 *Cygni*; ω^3 *Cygni*; ψ *Cygni*; 52 *Cygni*; P *XIX.*, 276; P *XIX.*, 149; Σ 2705; Σ 2666; Σ 2607; Σ 2708; 32 *Cygni*; ν^1 *Draconis*; 39 *Draconis*; Σ 2420; Σ 2078; Σ 2348; Σ 2403; 46 *Draconis*; Σ 2082; Σ 2922; Σ 2894; Σ 946; Σ 958; Σ 1338; β *Lyræ*; ζ *Lyræ*; ϵ^1 *Lyræ*; η *Lyræ*; 17 *Lyræ*; Σ 2472, 2473; δ^1 and δ^2 *Lyræ*; θ *Lyræ*; Σ 2372; *B. A. C.* 6468; Σ 331; 12 *Persei*; 57 *Persei*; Σ 533; Σ 1561;

Σ 1415; B.D. +54°, 1556; Σ 1559; Σ 791; Σ 794; Σ 802; Σ 1024; Σ 1025; Σ 1033; Σ 1039; Σ 1050; Σ 1054; Σ 1070; Σ 1075; Σ 2291; Σ 2305; Σ 2340; Σ 2349; Σ 2378; Σ 2376; Σ 2393; Σ 3130; Σ 2421; Σ 2431; Σ 2441; Σ 1462.

The meridian observations of red stars were finished last summer, and are now in preparation for printing. It is contemplated to devote the meridian circle, in connection with the new chronograph, to a re-examination of Argelander's southern zones between −15° and −20°.

Royal Observatory, Edinburgh.

During the past year the daily electric time-signals of ball and gun, together with supervisions of controlled clocks over Edinburgh city, have been carried out, with the usual attention to everything connected with their regularity and astronomical truth. The bi-diurnal meteorological observations at 55 stations of the Scottish Meteorological Society have also been computed and discussed for the Registrar-General of Births, Deaths, &c. in Scotland, and have been printed by that officer in his monthly and quarterly reports.

A meeting of the Board of Visitors was held in April, at which steps were taken to endeavour to induce the Government to have the requisite instrumental renovations, &c., carried out as soon as possible.

The first assistant astronomer, Mr. Alexander Wallace, M.A., having reached the age of 77, after a hard and continuous service of 46 years, has resigned.

Glasgow Observatory.

The astronomical operations at the Glasgow Observatory during the past year have been devoted almost wholly to the laborious work of preparing for the press the Star Catalogue alluded to in the last Annual Report of the Council. The Catalogue is now being printed, and Professor Grant expects that it will be ready for publication early in the spring of next year.

Kew Observatory.

The preliminary reductions of the measurements of the Kew solar negatives having been completed in January last, a re-examination of the pictures was made with the object of classifying the spots according to a scale of figure and magni-

tude. This being now terminated, the reduction to heliocentric elements of the pictures from January 1864 to April 1872 is rapidly progressing.

These operations have all been conducted under the direction and at the expense of Mr. De La Rue.

The eye observations of the Sun, after the method of Hofrath Schwabe, have been made on 246 days, in order to maintain for the present the continuity of the Kew records of Sun-spots. The Sun's surface was observed to be free from spots on 27 of those days.

A catalogue of the whole of the solar photographs taken at Kew during a decade, 1862 to 1872, has been prepared and forwarded to the Solar Committee of the Science and Art Department.

At the request of the Council of the Royal Astronomical Society, the valuable collection of MSS. containing the memorable series of Sun-spot observations made by Hofrath Schwabe, of Dessau, during the years 1825 to 1867, which had been deposited in the Library of the Observatory—the first volumes since 1865—was transferred to the Society's Library at Burlington House, London. In order, however, to render the collection of Sun-spot observations at Kew as complete as possible, and to prevent the total loss of the observations in case of fire, the Committee ordered a complete copy of the solar drawings to be made.

This was accordingly done, and accurate tracings made of every one of Schwabe's drawings. These were pasted into blank books, and any important notes were transcribed at the same time.

The Observatory, therefore, now possesses a complete record of the condition of the Sun's surface, extending from November 1825 to the present date.

The Magnetical and Meteorological Observations, which principally form the work of the Observatory, have been continued as in former years, and experimental work and the verification of instruments have also largely occupied the attention of the staff.

Liverpool Observatory, Bidston, Birkenhead.

In this Observatory the Mersey Docks and Harbour Board have provided very perfect arrangements for the testing of nautical instruments. The owner or commander of any ship for which dock rates are paid in the Port of Liverpool may have the ship's chronometers tested gratuitously in three definite temperatures by sending them to the Observatory. This privilege is also extended to chronometer-makers, who are allowed to send a limited number of nautical timekeepers periodically to be tested.

A considerable proportion of the chronometers tested during the past three years have the words "Auxiliary Compensation" engraved on their dials; but the average thermal error in these instruments has been found to be quite as large as that found in timekeepers in which no deviation from the ordinary construction is said to have been made.

With the means provided at this Observatory by the Mersey Docks and Harbour Board the thermal error can be very accurately obtained, and the application of corrections to the rates, due to change of temperature, is now rendered so easy that the mariner finds no more difficulty in using a variable rate dependent on the temperature than in using one uniform rate for all climates. The correction of the rates for thermal error has led to the discovery of a small, but very systematic, difference between the sea and shore rates of chronometers. With very few exceptions, chronometers used in steamships have been found to go slower at sea than on shore, the amount in different instruments ranging from a small fraction of a second to upwards of one second a day. This change of rate is probably caused by the motion of the ship. It is small in comparison with the thermal error, and is only shown in cases where the corrections for change of temperature have been carefully applied at sea during the voyage.

The regularity of the performance of chronometers is not such as to admit of the thermal error being found in a few days. In some timekeepers five weeks is found to be sufficient for a fairly good result to be obtained, but in others a much longer period is required.

Steamships, as a rule, are only a short time in port, and although it is very desirable to watch the performance of the chronometers during this period, so as to ascertain that no great change has taken place, the rates so obtained are found to be only rough approximations to the rates made by the timekeepers during the subsequent voyage. When a careful record is kept of the temperatures to which chronometers are exposed at sea, and the corrections due to change of temperature are applied, the differences between calculation and observation on the preceding voyage are found to be the best corrections to apply to the old rates in order to find the most probable rates for the next voyage. The average error for the mean of three fairly good chronometers treated in this way is found to be between three and four miles of longitude on the equator for a voyage of one hundred days.

Radcliffe Observatory, Oxford.

The Transit Circle has been cleaned, readjusted, and brought into regular use during the past year. 1270 observations of

Right Ascensions and 2059 Circle observations have been made and reduced. The Moon has been observed 50 times on the meridian.

132 measures of the position-angles and distances of double stars, and some measures of the diameters of *Mars* have been made with the Heliometer. These measures have been made with the reversions necessary to secure accuracy with this instrument.

The Solar Eclipse of 1880, December 31, was well observed here, and some measures of the chords made with the Heliometer. Ceraski's variable was observed on 13 nights, and continuously watched for 6 nights.

The photographic meteorological instruments have been renewed, and are now working in a perfectly satisfactory manner. The volume of Astronomical Results for 1876 has been completed, published and distributed, and a volume containing the Meteorological Observations 1876–1879 has also been published.

Oxford University Observatory.

The astronomical work undertaken since the last Annual Report in the *Monthly Notices* is as follows :—

1. Observations of the parabolic comets, Schäberle, Hartwig, Swift and Pechüle; of the periodic comet of Faye fourteen nights' observations have been secured.

2. Observations of 280 stars in the Group 39 Messier have now been completed. It was found necessary to reobserve the difference of Right Ascension with an altered inclination of the micrometer bar to the parallel, in order to secure as much precision herein as was obtained for the difference of N.P.D. with the original and less inclined position. The reductions are in a forward state. It may possess some interest to astronomers to be informed that a very successful application of the driving clock of the Grubb Equatoreal to a modified form of the Morse Telegraph has been made, whereby a very serviceable and accurate chronograph has been obtained, which has been successfully used in the observations of the forementioned group of stars. A chronograph of some form seems indispensable for such measures.

3. Observations of the Binary Stars ξ *Ursæ Majoris* and 70 *Ophiuchi* have been made, with the view of ascertaining how far they accord with the places of the components as computed from the elements of the orbits obtained by the somewhat novel process adopted in this Observatory. The results in the case of ξ *Ursæ Majoris* are of a highly satisfactory character. In passing over an arc of 50° since the orbit was computed there is, after the lapse of 6 years, a discrepancy of less than a degree in position-angle, and of less than a tenth of a second of arc in

distance. This is, it is believed, a closer degree of accord than applies to any other set of elements hitherto obtained. In the case of 70 *Ophiuchi* the accordance of the observed and computed position-angle is as satisfactory as in the foregoing case. Particulars will be communicated to the Society at the March meeting.

4. The computations for the Lunar Physical Libration are now completed, and the main result has been communicated to the Society. The general account of the whole process is in course of preparation for the press.

5. In the October term it was thought advisable to invite members of the University to visit the Observatory during the somewhat remarkable apparition of the planets *Jupiter* and *Saturn*. It was gratifying to find that very nearly 300 students and senior members of the University availed themselves of the opportunity. A few occasional lectures on the phenomena presented were given on successive evenings. In conjunction with Mr. Grubb, a very inexpensive form of small Equatoreal Telescope, of either $2\frac{1}{2}$ or 3 inches' aperture, has been arranged for incipient astronomers. This instrument is found, on trial, to be admirable in its optical and mechanical performance.

Stonyhurst Observatory.

The astronomical work at this Observatory has been considerably increased during the past twelve months, but without interfering in the least with the meteorological and magnetic departments. The large automatic spectroscope, which came into daily use in November 1879 has been employed for the measurement of the chromosphere on every favourable occasion; and a special assistant has been appointed to the duty of studying the chromosphere, and of making a daily sketch of all Sun-spot phenomena. The whole chromosphere has been measured on 45 occasions, and parts of it on 19 other days. The highest prominences were seen in November, when they attained a maximum height of $2'28''$. The dispersive power of the spectroscope has been increased lately by the addition of a Christie half-prism, and now the greatest dispersion is equal to that of 36 prisms of 60°.

The new sunshine recorder, which was erected in March 1880, has served, in connection with the spectroscope, to show the large number of days on which the sun may be shining brightly, and yet the state of the atmosphere prevent any reliable measures of the chromosphere.

The observation of *Jupiter's* satellites and of occultations of stars by the Moon has been continued as usual.

A long search for the ultra-Neptunian planet, indicated by the researches of Professor G. Forbes and Mr. D. P. Todd, has

not as yet resulted in the detection of any body that has done more than raise a passing suspicion of its planetary nature. The observations are being continued on every clear moonless night.

On December 31, preparations were made for observing chromospheric contacts, and also for taking a series of photographs of the Sun during the progress of the partial eclipse, but a cloudless morning was followed by a sunless afternoon, and a momentary break in the clouds afforded the only glimpse of the Sun in the course of the afternoon. This, however, sufficed to show that the first contact must have been at least some minutes later than the computed time. The weather was equally unfortunate during the week of the November meteors.

During the past year a large automatic spectroscope has been sent to the new Observatory of Kalocsa, and other instruments to the observatories of Manila and Trikawei.

Temple Observatory, Rugby.

The work of the past year has been chiefly the measurement of positions and distances of double and multiple stars, 421 complete sets of measures having been made by Mr. Seabroke, Mr. Hodges, and Mr. Percy Smith with the Alvan Clark Refractor.

The results of double-star observations of the last three years have been prepared for publication, and will appear in the next volume of the *Memoirs* of the Society.

A number of measures of position of a few double stars, whose angles are fixed or nearly so, have been made with the observer's head in various positions, and while making various angles with the horizon for the detection and estimation of errors in measuring the position of double stars. Speaking generally, from what has been already done, there is a tendency to place the position wires out of parallelism with the line joining the stars in the direction of the horizon, irrespective of the position of the observer's eyes.

Some few measures of the velocity of motion of stars in the line of sight have been made with the spectroscope, having a power of 6 prisms of 60° on the reflector.

The Observatory has been open for the usual hour every fine evening for members of the School, who are taught the uses of the equatoreal and transit.

Mr. Barclay's Observatory, Leyton, Essex.

During the past year the work has been carried on in a systematic manner, the main feature being observations of binary stars. Numerous comet observations have been made, as well

as observations of *Jupiter's* and *Saturn's* satellites. A new wire micrometer, by Cooke, it is hoped, will soon be added to the list of instruments.

Mr. Campbell's Observatory, Arkley, Barnet.

During the past year considerable progress has been made in observing the transits of the lunar Crater Murchison A, with the view of determining the value of the parallactic inequality in the motion of the Moon, so as to obtain a better determination of the Solar parallax.

The extremely unfavourable weather has materially retarded the work; but during the year 53 observations were obtained, and are now fully reduced.

During the latter part of the year, whenever possible, observations were made of both the limb and the crater, so as to enable comparisons to be made between the apparent errors of the Moon as determined by each class of observation.

Through the courtesy of Professor Winnecke, who has had corresponding observations made at Strassburg, it has been possible to compare the Arkley observations with simultaneous observations made at Strassburg. At both Observatories the conclusion has been reached that the observations of a crater on the Moon can be made with far greater accuracy than those of the limb—in fact, with an accuracy surpassing that of a star.

During the year a new collimating telescope has been designed and mounted, with the view of more certainly determining the error in both collimation and azimuth of the Transit instrument. It is proposed to carefully test this during the coming year, to see if the practical advantages are as great as were anticipated.

A series of observations has also been commenced with the Alvan Clark Equatoreal, with the object of determining the inequalities on the limb, and their influence on the apparent error of the Moon as determined by observations of the transit of the lunar limb. The same series of observations will also serve to determine the variation in the irradiation of the Moon's limb as seen under different conditions.

Mr. Common's Observatory.

During the past year the weather has not been at all favourable for astronomical observations. Faye's Comet was found on August 8, 1880. Swift's Comet has been observed to January 5, 1881, with the 36-inch reflector. Photographs of *Jupiter* have

been taken showing the shadow of the third satellite on the disc. The 18-inch and 36-inch telescopes have been taken down, and the 36-inch erected on a new site some four hundred yards further north—the position of the Observatory from the Ordnance Map being now, lat. N. 51° 31′ 7″, long. W. 1′ 13″.

Colonel Cooper's Observatory, Markree.

During this year observations have been made of a number of the most interesting binary stars from a working catalogue, the contents of which it is expected will be finished off in the course of the coming year. The magnitude and colour of red stars in Birmingham's Catalogue have been also noted. At the end of the year some observations of comets were made with the old square bar micrometer. The dimensions of some major planets have been measured, and the phenomena of their satellites, as well as the spots on their surface, have been observed. A sunshine recorder was at the commencement of the year added to the meteorological instruments.

The Earl of Crawford's Observatory, Dun Echt.

The Transit Circle has been used during the past year for finding the places of a few comparison stars, as well as for determining the time. On April 9, the telescope, which had originally been focussed on the pole-star, was re-adjusted with a Bohnenberger eye-piece on the reflected images of the wires as seen in quicksilver. The slight change thus made has greatly improved the visibility of the reflected images in making nadir observations without injuring the definition on stars. A time-gun is fired every Saturday at Greenwich mean-noon.

The 15·06-inch refractor is in thorough working order, the electrical control acting perfectly under great changes of load in all temperatures. The great gale of 1879, December 28, partly displaced the dome; but the addition of an extra pair of guide-wheels has, it is believed, made the structure capable of withstanding a much more violent storm. The following comets have been observed for place:—1880 *b* (Schäberle) 10 times; Faye's Comet, once; *e* (Hartwig) 5 times; and Swift's second comet, *f*, 14 times. This last comet was also independently discovered at Dun Echt by Mr. J. G. Lohse on November 7. The spectrum of Hartwig's Comet was observed on 3 nights; that of Swift's Comet, which only showed a faint trace of one band, and that of Pechüle's comet, *f*, were each observed on one night. An orbit of the great Southern Comet, *a*, was computed from three

rough observations received from Mr. Gill, and its probable identity with the great comet of 1843 pointed out. On this basis a search was kindly made by Mr. Pratt at Brighton, and also at Dun Echt. We now know that, although near the place indicated, the comet was too faint to be seen. Orbits and ephemerides of comets *b* and *c* were computed and, as well as those of *a*, communicated to the *Astronomische Nachrichten*. The first news of the comet seen by Mr. L. Swift on August 11, reached Dun Echt twenty days afterwards in No. 2331 of the *Astr. Nachr.*; a long but unsuccessful search was made. Another comet, announced by Mr. Cooper of Sheffield, was also sought for in vain.

A number of sweeps have been made with a prism between the eye-piece and the object-glass on the plan devised by Professor E. Pickering. In this way Dr. Copeland discovered a small, bi-nuclear, planetary nebula on November 18; its spectrum contains a fourth line distinct from the fourth line of the spectrum of the great nebula in *Orion*.

Some spectra of variable stars have been examined and a few double stars and other objects measured. The chief results have been published in the *Monthly Notices*, *Astronomische Nachrichten*, or *Urania*.

Thirteen Dun Echt circulars have been distributed during the year. Of these 1 related to a supposed trans-Neptunian planet, 2 to variable stars, 1 to the new nebula, and the rest to comets.

In the laboratory Mr. Lohse has determined the optical constants and specific gravities of 10 sample prisms. The whole of the laboratory and library are now warmed by hot-water pipes. The book-shelving has been greatly extended.

In September, M. Perrotin, of Nice, visited the Observatory, devoting two days to examining the instruments, &c.

Mr. Edward Crossley's Observatory, Bermerside, Halifax.

No change in the class of observations made here has taken place since the last Report. As before, the measurement of double stars, the observation of the phenomena of the satellites of *Jupiter* and *Saturn*, sketches of *Jupiter*, transits of the "red spot" on *Jupiter*, and the daily reading of the usual set of meteorological instruments, constitute the work of this observatory.

The instrument used is the same as in previous years—viz. the $9\frac{1}{3}$-inch refractor by Cooke. About a year ago the edge of the declination circle, which is $\frac{3}{4}$-inch broad, was divided boldly into degrees, with white paint on a black ground so as to be easily seen from the eye-end of the telescope. A vernier was found unnecessary, an index point being quite sufficient. Parts

of a degree are easily set by estimation, so as always to bring the object into the centre of the finder. This has been found so convenient in practice that we wish to draw the attention of observers who still go on setting for an object by means of the finely divided declination circle to the great saving of time and trouble secured by the above arrangement. In our case an ordinary lamp held in the hand enables us to set the instrument quickly in declination without the aid of reading microscope or telescope of any kind.

The observations of the satellites of *Jupiter* and *Saturn* for the year ending December 31, 1880, are now ready for presentation to the Society, and the double-star measures made here since 1876 will shortly be ready.

Mr. Huggins's Observatory, Upper Tulse Hill.

During the past year more perfect photographs of the spectra of *Rigel*, *Betelgeux*, *Aldebaran* and *Capella* have been obtained.

In the arrangement described in the last Report *Rigel* will have its place between *α Cygni* and *α Aquilæ*.

The photographic spectrum of *Capella* resembles the solar spectrum very closely, and appears to be a star in the same physical stage as our Sun.

The spectra of *Betelgeux* and *Aldebaran* are very difficult to photograph. In the case of *Betelgeux* an exposure forty times greater than would have been necessary for a strong spectrum of *Sirius* gave but a faint spectrum of limited extent. The photograph is strongest about G, and ends abruptly a little beyond H.

The spectrum of *Aldebaran*, with an exposure fifty times greater than *Sirius* would have required, extends from about F to H, with a faint trace of the more refrangible region. About fifty lines may be measured in this spectrum.

There seems good reason to believe that these photographic spectra indicate some of the life-changes through which the stars pass, and that the stars observed may be arranged in the following order:—

Sirius . . . Vega.	α Cygni.
η Ursæ Majoris.	. . .
α Virginis.	Capella. The Sun.
α Aquilæ.	Arcturus.
Rigel.	Aldebaran.
	Betelgeux ?

Attempts have been made to photograph the spectrum of the Nebula in *Orion* and of the ring Nebula in *Lyra*, but hitherto

without success. Further attempts, with an altered form of apparatus, are in progress.

In the laboratory a remarkable group of lines in the ultra-violet (W. L. 3276 to W. L. 3062) was photographed in the flames of hydrogen and of several hydro-carbons. This group represents the spectrum of water in the form of luminous vapour, and explains the remarkable power of exciting fluorescence which was observed by Professor Stokes in these flames in the year 1852.

The Earl of Rosse's Observatory, Birr Castle.

During the year 1880 some observations of nebulæ were made by Mr. Keating up to April 1, when his engagement terminated. Work was not resumed until after November 1, when Dr. Boeddicker, late of the Hamburg Seewarte, undertook the duties. He has since made some sketches of the planet *Jupiter*, and some preliminary determinations of lunar heat have been made with the view of ascertaining what probability there is of the subject being further advanced, now that the 3-foot telescope is provided with an equatoreal mounting, and by taking further precautions against errors. Observations have been recorded on 35 nights during the year.

The meteorological observations at 9 a.m. and 9 p.m. have been continued regularly, also at 8 a.m. and 6 p.m. Greenwich time for telegraphic reports.

Since the last Annual Report, Part III. of the "Observations of Nebulæ and Clusters," &c., has been published, and a good many copies distributed. Should any person who has received Parts I. and II. (sewed together), but has not received Part III., or *vice versâ*, notify the fact, the missing part will be sent. Part III. completes the work.

Colonel Tomline's Observatory, Orwell Park.

The work of the past year at this Observatory has been continued upon much the same lines as in former years. All the comets that have been visible have been more or less observed, and especially good series of Schäberle's and Hartwig's Comets have been secured. The former was kept in view until September 9, and the latter until November 25. Pechüle's Comet is still under observation at the end of the year.

The completed observations of Brorsen's Comet in 1879 were supplied to the *Astronomische Nachrichten* early in the year,

but there yet remain considerable arrears of cometary work which have not been fully reduced. Efforts will be made at once to prepare these for the press, along with those of 1880, with the view to their speedy publication.

The eclipse of the Sun on December 31 was well seen, but unfortunately the state of the atmosphere did not admit of very accurate observation.

A number of occultations of stars by the Moon have been observed, and it is proposed in future to watch for the unpredicted occultations of small stars at the dark limb of the Moon during the early days of each lunation, in the hope of detecting and elucidating the phenomenon of projection on the limb. Some trials already made lead the observer to believe that a considerable number of occultations may in this way be observed in a comparatively short space of time at various points on the limb.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets.

During the past year the following additional minor planets have been discovered, thus increasing the number of the group to 219:—

Number.	Name of Planet.	Date of Discovery. 1880.	Name of Discoverer.	Mean Distance.
(213)	Lilæa	February 16	Peters	2·746
(214)		March 1	Palisa	2·611
(215)	Œnone	April 7	Knorre	2·768
(216)		April 10	Palisa	2·794
(217)		August 30	Coggia	3·051
(218)		September 4	Palisa	2·702
(219)		September 30	Palisa	2·382

Several of the minor planets discovered in 1879, as well as in the past year, have not yet been named.

M. Niesten has given in the *Annuaire de l'Observatoire Royal de Bruxelles* an interesting *résumé* of the relative elements of the orbits of the first 216 minor planets, classifying them according to their sidereal periods, longitudes of the perihelion and node, excentricities, inclinations, and mean distances from the Sun, with general remarks on their magnitudes, and on the probable origin of the group. From one of these tabular statements the following numbers are extracted, from which a clear notion is obtained of the relative mean distances of the minor planets, and of the breadth of the zone in the solar system occupied by this remarkable group of planets. Taking the mean distance of the Earth as unity, the mean distances of *Medusa*, *Flora*, and *Ariadne*, the three nearest minor planets, lie between 2·00 and 2·25, while forty-five lie between 2·25 and 2·50, seventy-one between 2·50 and 2·75, thirty-nine between 2·75 and 3·00, thirty-eight between 3·00 and 3·25, seven between 3·25 and 3·50, and two between 3·50 and 4·00. It will thus be seen that the great mass of minor planets are included within a zone extending from 2·25 to 3·25, and that in this zone the mean distances of the greater number lie between 2·55 and 2·80, showing, as might be expected, that the inner portion of the ring of known asteroids is comparatively richer than the outer portion. E. D.

The Comets of 1880.

Six comets, including the periodical comet of Faye, have been satisfactorily observed during the past year. A few brief details of each are given below, in the order of their discovery or first observation.

1. *The Great Southern Comet*, 1880 (*a*).—This remarkable comet was a conspicuous object in the sky of the southern hemisphere during the first half of February. The first announcement in Europe of its discovery was a telegram dated February 5, sent by Dr. Gould, of Cordoba, to the late Professor C. A. F. Peters, stating that a great comet was passing the Sun northwards. This was followed by a second telegram, dated February 6, to the effect that the comet was then moving southwards. This uncertainty in the direction of the comet's motion was not explained till the independent announcement of its discovery was received by mail from the Cape. The tail appears to have been noticed on the evening of February 1, by several persons in Australia, South America, and at the Cape; but it was not recognised as a comet till the following evening, when sketches and observations were made at Cordoba by Dr. Gould; at Sea Point, west of the Table Mountain, Cape of Good Hope, by Mr. Gill; at Melbourne, by Mr. Ellery; at Adelaide, by Mr. Todd; and at Castlemaine, Victoria, by Dr. Bone. The tail was also noticed by other observers in Australia, South America, and at the Cape.

According to Dr. Gould's observations, the tail of the comet appeared as a luminous band, extending from the horizon in the S.S.W. about forty degrees towards γ *Toucanæ*, passing near δ and β *Gruis*, and about $1\frac{1}{2}$ to $2\frac{1}{2}$ degrees in breadth. On February 4 it could be traced as far as α *Eridani*. On this day the nucleus was seen by Dr. Gould at Cordoba, and by Dr. Bone at Castlemaine, but it was excessively faint. At Melbourne it was not observed before February 9, and at Sydney before February 13. At the Cape, owing to the amount of haze near the horizon, and the small optical power of the instrument employed, the nucleus was not seen at Sea Point where the tail was first noticed; and even at the Royal Observatory, Cape Town, Mr. Gill failed to see anything like a nucleus till February 9. From this day to February 15 observations were secured daily by Mr. Gill and Mr. Finlay with the $8\frac{1}{2}$-feet equatoreal. The nucleus continued to be observed by Mr. Ellery till February 17, and by Dr. Gould till February 19. Various sets of elements of the orbit of the comet have been calculated from the observed positions of the nucleus by several persons, including Dr. Copeland, Mr. Finlay, Dr. Gould, Mr. Hind, Mr. Meyer, and Mr. Tebbutt. The elements bear a close resemblance to those of the Great Comet of 1843, also celebrated for its length of tail, which

alone was visible in England, where the nucleus was below the horizon during the apparition. There seems a possibility that the two comets may be identical, but whether they are so or not must remain for the present an open question. For more details respecting the Great Southern Comet the reader is referred to the observers' statements in the *Monthly Notices*, Vol. xl. Nos. 5, 6, and 9, Vol. xli. No. 2, and in the *Astronomische Nachrichten*, Nos. 2307 and 2308. Professor Kirkwood has made some interesting speculations on the supposed identity of this comet with the comet of 1843 in the *Observatory*, Vol. iii. p. 590.

2. *Schäberle*, 1880 (*b*).—This comet was discovered by Mr. J. M. Schäberle, assistant at the Observatory at Ann Arbor, U.S., shortly before midnight on April 6. It was very faint, its nucleus being about the tenth magnitude, accompanied by a tail about 3′ in length. It was well observed, both in the United States and Europe, and several sets of elements have been calculated. Those by Mr. Hind, derived from an observation made at Strassburg by Professor Winnecke, on April 11, and two observations by Lieut.-Col. Tupman at Blackheath, on April 27 and May 8, will be found in the May number of the *Monthly Notices*. Elements by Professor Safford and M. Bigourdan are inserted in the June number.

3. *Faye*, 1880 (*c*).—This excessively faint but interesting periodical comet was observed by Mr. Common, at Ealing, on several occasions, with his 3-feet telescope. He remarks that "when first seen, on August 2, 10^h, it was faint, round, and a little brighter towards the middle." This comet has also been seen by several observers, including M. Tempel, at Florence; M. Dunér, at Lund; Dr. Pechüle, at Copenhagen; and M. Bigourdan, at Paris. It was detected by the aid of Dr. Axel Möller's excellent ephemeris, the observed errors of which have been found to be no greater than about $2^s{\cdot}5$ in Right Ascension, and 2″ in Declination. The President will explain in his address the principal points of interest in Dr. Möller's important researches on the orbit of this comet.

4. *Hartwig*, 1880 (*d*).—This comet was discovered by Dr. Hartwig, at Strassburg, on September 29, with a brilliant nucleus and a tail two degrees in length. It was discovered independently at Ann Arbor, by Professor Harrington, on September 30, and by Mr. Baxendell, at Southport, on October 3. This comet, which passed its perihelion on September 6, was favourably observed at most of the principal observatories. At Brussels it appeared round, with a diameter of about three or four minutes, and a nucleus equal in brightness to a star of the fifth magnitude. The comet was visible in telescopes with small aperture, and it was occasionally seen by the naked eye. Its spectrum was examined by several observers. At the Royal Observatory, Greenwich, it was observed on three separate days, when it was found to consist of the three usual cometary bands, the nucleus giving a continuous spectrum. Some valuable spectroscopic ob-

servations of this comet, made by Professor C. A. Young, may be found in the December number of the *Observatory*, vol. iii. p. 645.

Professor Winnecke has suggested the possibility of this comet being identical with the comets of 1382, 1444, and 1569, and perhaps with that of 1506, from which he assumes a probable period of $62\frac{1}{3}$ years.

5. *Swift*, 1880 (*e*).—This comet was discovered by Professor Lewis Swift, of Rochester, N.Y., on October 10, but owing to unfavourable weather and want of information, it was not observed in Europe till October 25, when M. Block, at Odessa, picked it up. Dr. Lohse detected it independently at Dunecht, on November 7, believing that the object was a new comet. It had, however, been observed in America on October 21, 25, and 28, and Mr. S. C. Chandler, jun., was thus enabled to calculate the elements of its orbit, which agree sensibly with those of Comet III. 1869 (Tempel). There seems to be no doubt that the two comets are identical. Mr. Chandler has also discussed all the observations of Comet III. 1869, 39 in number; and from three normal places he has deduced elements on three different hypotheses of a parabola, an ellipse of 4,006 days (or about 11 years), and an ellipse of 2,003 days (or about $5\frac{1}{2}$ years). From the smallness of the residuals in the third hypothesis, Mr. Chandler concludes that the true period will prove to be about $5\frac{1}{2}$ years. MM. Schulhof and Bossert have arrived independently at a similar conclusion, from a discussion of the observations of the comet at the present appearance, from October 25 to December 5. The agreement of the different sets of elements is perfect, and leaves little doubt of the accuracy of the conclusion, which is further confirmed by elements calculated by Prof. E. Frisby from three observations made with the Transit Circle at Washington by Prof. Eastman on October 25, November 7 and 20, in which no assumptions about any periodic time have been made. The period found from these observations is about 2178 days, or a little less than six years (*Astron. Nachr.* No. 2359). An excellent series of observations of this comet has been made at the Dunecht Observatory.

6. *Pechüle*, 1880 (*f*).—The last comet of the year was discovered at Copenhagen on December 16, by Dr. Pechüle. It was small, but bright, 1′ in diameter, with a central condensation. According to the elements calculated by Dr. Holetschek, the comet was in perihelion on November 10. It has been very generally observed, and most of the results are given in recent numbers of the *Astronomische Nachrichten*.

In addition to these six comets, an object was observed by Mr. Swift, at Rochester, N.Y., on August 11, in *Ursa Major*, in R.A. $11^h\ 28^m$ and N.P.D. 22°, and supposed by him to be a faint comet. No motion was detected in one hour. It was lost through cloudy weather on the days succeeding the day of observation, and has not been again seen. E. D.

New Planetary Nebulæ.

The comparatively speaking small number of these objects has been increased by three new ones found during the past year. Professor Pickering has instituted a systematic search for celestial objects with a gaseous or otherwise remarkable spectrum, using a telescope with a direct-vision prism inserted between the object-glass and the eyepiece. This search has been rewarded by the finding of three very small and stellar-looking planetary nebulæ, the positions of which for 1880 are :—

R. A.	$18^h\ 4^m\ 19^s$	Dec. $-28°\ 12'$
	$18\ 14\ 23$	$-26\ 53$
	$18\ 25\ 10$	$-25\ 13$

About an eighth of the visible heavens has so far been explored at the Harvard College Observatory, but no other monochromatic objects have been found; while, on the other hand, some remarkable star-spectra have been met with.

Using Prof. Pickering's method of search Dr. Copeland has succeeded in finding a fourth new planetary nebula in

R. A. $21^h\ 2^m{\cdot}2$, Dec. $+47°\ 22'$.

This object is remarkable for having, in addition to the three usual nebular lines, a fourth line at W. L. 4694, which probably is the same as the one seen by Dr. Huggins in G. C. 4964. This nebula is, however, not new, but was found by Mr. Burnham in 1873.

In this connection it also deserves notice that Schmidt's new star in *Cygnus*, which, in the autumn of 1877, was found by Dr. Copeland to have become monochromatic, is now by Professor Pickering announced to have lost this peculiarity, and to show a continuous spectrum. J. L. E. D.

Ceraski's new Variable Star.

The star B.D.+81° No. 25 was, on June 23, 1880, discovered to be variable by M. Ceraski of the Moscow Observatory. Further observation proved it to be a remarkable variable star of the Algol type, and a period of $2{\cdot}492886$ days was assigned to it by Prof. Julius Schmidt of Athens, from minima observed by him in August and October (*Astronomische Nachrichten*, No. 2346). More recently (*Astronomische Nachrichten*, No. 2358), from a discussion of fourteen minima observed between August 2 and December 12, Prof. Schmidt has been led to infer a gradual increase in the period, each period being longer than the preceding by $5^s{\cdot}25$. For the prediction of future minima Prof. Schmidt gives the following elements :—

1880, Dec. $7^d\ 10^h\ 6^m{\cdot}7$ Athens M. T. $+2^d\ 11^h\ 50^m{\cdot}812$ E,

where E is the number of periods elapsed. A further correction of $0^{m}\cdot08753$ must be added for the increase of the length of each succeeding period.

The star appears to go through its changes in about six hours, for two hours of which it remains at minimum, with little, if any, variation of light. Its range of magnitude is from $7^{m}\cdot2$ to $9^{m}\cdot3$, and its colour, which, when it is at full light, is a bright bluish-white, changes to a decided orange as it falls to minimum. Two small companions of the 12 and 13 mag. have been measured in position and distance by Dr. Copeland with the Dun Echt Equatoreal with the following results: 12 mag., Pos. 59°·3, Dist. 14″·9; 13 mag. Pos. 323°·7, Dist. 22″·1. G. K.

Mr. Lewis Boss's Declinations of the Fixed Stars.

The United States Northern Boundary Commission has recently published a very important catalogue of the Standard Declinations of 500 Stars, compiled and prepared by Mr. Lewis Boss, the Director of the Dudley Observatory. The catalogue, which originally was intended for the latitude work of the above Survey, became considerably enlarged in its preparation, so as to include a complete investigation and discussion of all modern original catalogues, in order to reconcile the systematic discordances found to exist among independent declination determinations of the highest rank. The work has been carried out in a very thorough and satisfactory manner, and the care exercised in the selection of stars, in the discussion of the various catalogues, and in the reduction of places to the mean epoch 1875·0, renders Mr. Boss's results one of the most important contributions to the subject which astronomy has received.

Mr. Boss assumes, and probably correctly assumes, that the interval of time between the group of early determinations of Bessel (1821), Struve (1824), and Argelander (1830), and the later ones at Leiden, Melbourne, Greenwich, and Washington, is quite sufficient for an independent judgment as to the approximate accuracy and consequent weight of Bradley's results, and that a reliable system of corrections to the various catalogues may be founded on a discussion of recent catalogues alone, taking as the earliest that of Bessel for the mean epoch 1821.

The successive steps in the formation of the catalogue are:

1. The selection of stars, and particularly of a list of stars most frequently observed, to serve as the basis of the normal system, and as a medium of comparison between the various series of observations.

2. The formation of approximate positions and proper motions for the epoch 1875·0.

3. The computation of precession coefficients, and the reduc-

tion of the individual declinations to the required epochs, in order that the assumed declinations may be corrected by comparison with the observed values.

4. The selection of catalogues and series of observations, and the division into three classes.

5. The application to the declinations of these catalogues of certain corrections derived from inspection of the constants and methods of reduction.

6. The collection of results and formation of the approximate normal system from a discussion of the declinations of the fundamental and principal circumpolar stars, using observations only of sufficient independence and weight.

7. By the aid of the approximate corrections, to enlarge the number of standard declinations, and with these to derive the systematic corrections to the *Fundamenta.*

8. To ascertain corrections to the assumed declination and proper motion of each star, and then to compute definitive corrections and weights for all the catalogues, except those of the third class, with which final weights and corrections the definitive declinations are computed as they appear in the catalogue.

9. The computation of systematic corrections to catalogues of the third class.

The principles adopted for the selection of the stars divide them into five classes :

1. The fundamental and principal circumpolar stars which have been by common consent universally observed.

2. A class of stars less frequently observed, but with the observations so distributed in time that reliable determinations of declination and proper motion can be had without recourse to Bradley's observations ; and which, together with the fundamental stars, may serve to construct an approximate normal system for the epoch 1755.

3. A class of stars similar to the last, but lacking in satisfactory authorities for the epochs included between 1820 and 1840.

4. A considerable number of stars which do not furnish proper material for ascertaining systematic corrections to the principal authorities, but valuable for the purpose of perfecting the system of corrections adopted for a few catalogues of small weight.

5. The remaining declinations are such as depend on few authorities, practically of no service in ascertaining systematic corrections.

Nearly all authorities for declination have been selected by the author for use. A careful examination and discussion of each catalogue is furnished for the purpose of applying such corrections as may appear advisable from inspection. These corrections may be regarded as of three classes :—

First, those required on account of the reduction of the observations from apparent place to the true epoch of the cata-

logue, principally for nutation and the proper motion employed.

Second, corrections derived by special examination of the instrument or discussion of the observations which had been indicated but not applied in the results, including *errata*.

Third, corrections applied to certain annual catalogues to reduce the discordances in the results of separate years.

Under the designation of each catalogue are enumerated all the corrections which have actually been applied in the discussion. The investigation of original catalogues which follows will be found especially valuable. (It is unfortunate the author should have introduced a new method of designation for different catalogues, formed of the initial and final letters of the English names of the place where the catalogues were made. This gives some trouble in identification, especially to foreign astronomers, which might have been avoided.)

In considering the Greenwich catalogues, Mr. Boss discusses the R−D correction, and in this connection it is to be regretted that Mr. Christie's memoir on the Systematic Errors of the Greenwich North Polar Distances (*Memoirs of the Royal Astronomical Society*, vol. xlv.) was not published early enough for his use. From a discussion of approximate results, Mr. Boss adopts a mean residual flexure of $+0''.21$, and states that if the uniform value of sine flexure $+0''.21$ had been employed throughout the series, we should have had sufficiently good agreement between direct and reflection observations. He adds that this appears to throw discredit upon the value of flexure derived from opposing collimators. Mr. Christie states that the old law $a+b \sin z$ on the whole represents the observations better than the assumed law $a+b \sin z \cos^2 z$, and adds that "this conclusion if accepted would imply that the determination of flexure correction is erroneous."

In the assignment of weights, which Mr. Boss discusses in Section VI., in the first approximation to a normal system, he says, there is great difference in the quality of independent determinations of declination, which vary from such special investigations as those of Bessel (1821), Struve (1824), Argelander (Abo), and Pulkowa (1845)—where every precaution has been exercised to remedy the inevitable defects of instruments by variety in the circumstances of observation, and the utmost skill and rigour in the computations, with determinations of the various elements of atmospheric refraction—to those which assume their refractions from alien authority, which are made with non-reversible instruments and with little attention to those details of observation and reduction so essential in the delicate problem of measuring absolute declinations; and he justly says that it seems but reasonable to suppose that declinations of the former class are entitled to much greater confidence than those of the latter. He further adds that the weights assigned are not those which might seem to be required by comparisons with an ap-

proximate mean system, but are derived from an independent study of each catalogue, considered solely on the basis of internal evidence. He assigns very low weights to Greenwich catalogues compared with Pulkowa, Leiden, Bessel (1821), Struve (1824), and Argelander (Abo), but the final results show that the declinations of the Greenwich catalogues are quite as good as the others.

In Section VIII., Mr. Boss discusses the final corrections and weights, in which his examination of the systematic corrections and probable errors of each catalogue will be found most exhaustive.

The resulting catalogue of 500 stars comprises stars down to the 6·5 mag. in both hemispheres. The approximate R.A.'s are given, adopting, where possible, Professor Newcomb's standard R.A.'s and his corrections to the R.A.'s of other catalogues; the annual variation and secular variation in R.A. are appended. Accompanying the definitive declinations, Mr. Boss has usefully given columns containing the probable error and weight; the remaining columns are devoted to the annual variation with its probable error, secular variation and third term of precession, and proper motion.

The amount of labour and care Mr. Boss has bestowed on this important work, and the ability he has displayed in the discussion, entitle him justly to the gratitude of all astronomers.

E. B. K.

Professor Safford's Catalogues of the Declinations of Stars.

In the year 1873 the United States Lake Survey published an important Catalogue of the Declinations of 981 Stars for the latitude work of that Survey. This catalogue was prepared by Professor T. H. Safford, the stars ranging down to the 7·0 mag. and situated in R.A. 0^h to 2^h and 12^h to 24^h, and between the parallels of $+30°$ and $+60°$, reduced to the epoch 1875·0. The places were deduced from most modern catalogues. For stars which were not contained in Mädler's Bradley or the catalogue of the Astronomische Gesellschaft, Professor Safford himself has deduced proper motions by comparison with D'Agelet, Fedorenko, Lalande, Piazzi, Groombridge, and a few others. Very few stars are contained in the catalogue which are not derived from two original catalogues. The R.A., with its annual variation and proper motion, is given, and to the Declinations, which are calculated to $0''·1$, are appended the annual precession, proper motion, and logs. a', b', c', d'.

During the past year the Engineer Department of the United States army has published a more extensive and valuable catalogue by Professor Safford, being one of the mean declinations of 2018 stars from 0^h to 2^h and 12^h to 24^h Right Ascension, and 10° to 70° of North Declination for January 1, 1875. The stars are situated in those hours of R.A. most suitable for ob-

servation during the months of the year best adapted to the work of the United States Geographical Surveys.

It will be seen that this catalogue is an extension of the previous one of 981 stars, but there are certain differences which render it the more valuable. In this catalogue proper motion is included where given in the final catalogue; in that of the Lake Survey, only where the star is determined by Mädler. In the latter catalogue systematic corrections were used in part; but in that of 2018 stars they are employed and have been applied in the details, which was not so in the first catalogue. Professor Safford states that he has found it necessary to classify the stars according to the degree of accuracy with which their proper motions have been determined.

The stars are divided into four classes, as follows:—

AA. Those whose positions rest upon a great multitude of recent observations.

A. Those whose places have been well settled by at least three observations at each of two Observatories, or by a greater number of observations at one since 1860, or since 1855 when the older determinations give the proper motion with great certainty.

B. Those whose places have been but once so fixed since the same dates.

C. Those stars which had not been well observed by the older astronomers, Bradley, Piazzi, Lalande, and Groombridge, and which have not been lately observed. These stars are classed together for two reasons: first, that the observers at fixed Observatories may see at a glance what stars especially need redetermination in both elements; and second, that these stars may be used in latitude work only in case of absolute necessity.

The author's estimate of the probable error of the Declination for 1875·0 of an average star in each of these four classes is as follows:—

Class AA	±0″·18
„ A	±0″·28
„ B	±0″·43
„ C	±0″·7

In the preparation of the catalogue, Professor Safford has had the advantage of using Professor Auwers's re-reduction of Bradley, and the current Greenwich, Oxford, and Washington observations a year in advance of publication. The author particularly remarks upon having found some scattered and isolated determinations of Declination in connection with latitude work by Gauss, Argelander, Struve, Bessel, and others, which have proved of the highest precision. All modern catalogues have been consulted. Bessel's precessions have been used; for proper motion, the author employs Mädler's values (or an approximation of his own) in R.A., and in Declination he determined the value adopted by comparison of modern observations

with ancient. In combining positions, the following weights are used:—

1 Observation	. . .	Weight $\frac{1}{2}$
2 „	. . .	„ $\frac{3}{4}$
3 to 8 „	. . .	„ 1
9 „	or more .	„ $1\frac{1}{2}$ or 2

Professor Safford states that "the revision of the present catalogue by new observations need only be made for Class C;" and he goes on to make the following significant remarks: "I have been convinced by the present discussion that the ordinary meridian work of Observatories needs to be modified, if the accumulation of raw material, undiscussed and rendering discussion more and more difficult, is not to go on for an indefinite future. The subjects of stellar meridian observation in the northern hemisphere of the heavens now needing attention are these:—

"1. More thoroughly good fundamental determinations.

"2. The observation (aside from the zones) of those of Heis's stars which are not in the B.A.C.—about 2000 in number; these stars are as much needed as those in the B.A.C.

"3. The revision of doubtful cases, such as those in Class C of the present work.

"4. The regular observation every few years of stars of decided proper motion.

"Any other stellar observations need be only for special practical purposes."

These remarks are well worth the consideration of astronomers; likewise Professor Safford's concluding words: "I may remark that experience has shown the importance of keeping a continual watch over predicted star-positions, owing in part to the uncertainty of the older observations and the consequent difficulty of the prediction; it will therefore be well if any suspected stars are immediately made known to me, in order that any discrepancies may be detected by the newer observations now published and in progress." The catalogue includes some stars of the 8th mag. Annual precession and proper motion are given in both elements, and for Declination logs. a', b', c', d', are appended, the details of positions from which the definitive Declinations have been obtained being also given for every star. E. B. K.

The Parallax of α Centauri.

The large value of the parallax of *α Centauri* which Henderson deduced from his meridional observations made at the Cape in 1832–33, after Johnson had called attention to the large proper motion of this splendid double star, was substantially confirmed by the series of observations made by and under Maclear from

1839 to 1849, from which he derived $0''{\cdot}917 \pm 0''{\cdot}030$ as the resulting value of the parallax. And it was further supported by some series of observations made by Moesta at Santiago from 1860 to 1864, which give the value $0''{\cdot}880 \pm 0''{\cdot}068$ (*Astron. Nachr.* No. 1868). Both determinations depend on the measured zenith distances of the star, and are consequently subject to some sources of error, the effect of which, in mere differential observations, would be greatly diminished. From similar series of observations of the star *β Centauri*, which differs in declination only 33′ from *α* and is only 4° 33′ distant, Maclear and Moesta have likewise determined its parallax and have deduced the values—

Maclear	$0''{\cdot}470 \pm 0''{\cdot}044$.
Moesta	$0''{\cdot}213 \pm 0''{\cdot}069$.

As the annual proper motion of *β Centauri* does not exceed $0''{\cdot}1$, such a considerable parallax of the star is at least not very probable, and it becomes a question whether the deduced values do not rather represent the effect of periodical errors in the observations than the parallax itself. Since such periodical errors will be in great part eliminated in the observed differences of the observed zenith distances of *α* and *β Centauri*, the difference of the parallaxes of the two stars can be determined with far greater certainty than the parallaxes themselves, and, at the suggestion of Professor Winnecke, Mr. W. Elkin has, therefore, undertaken such a determination. On account of the rapid revolution of the two components of *α Centauri* round their common centre of gravity and the consequent variability of their proper motions, some investigations had first to be made for ascertaining their mutual position and the proper motion of their centre of gravity. The elements of the orbit of the binary star, which Elkin has deduced from the observed position-angles, are:

Time of periastre . .	1875·97	Periastre from node	54°·79	1860·0
Period	77ʸ·42	Node . . .	25·76	
Eccentricity . . .	0·5100	Inclination . .	79·52	

and the semi-axis from the observed distances $17''{\cdot}50$. These elements represent the micrometrical measurements within plausible limits, and are sufficiently near the truth for the intended purpose. Elkin's investigation of the proper motion of *α* relative to *β Centauri*, from a discussion of the mean places of the stars in the available star-catalogues, leaves the question undecided whether the centre of gravity of the two components of *α Centauri* differs from the middle point between them, and, consequently, whether their masses are not equal—a curious result, when the difference in their magnitudes is considered. The absolute proper motion of the middle point is found to be approximately $3''{\cdot}669$ in the direction of the position-angle 281°·75 for 1860.

All three stars α_1, α_2, and β *Centauri* have been observed by Maclear on the same day on 95 occasions, and these observations have then served for the determination of the difference of their parallaxes. The deduced values are:

Relative parallax of α_1 . $0''{\cdot}6014 \pm 0''{\cdot}0813$

„ „ α_2 . $0''{\cdot}4234 \pm 0''{\cdot}0899$;

the simple mean of which,

$$0''{\cdot}5124 \pm 0''{\cdot}0797,$$

is proposed by Elkin to be accepted as the final result of Maclear's observations.

Moesta's observations of α_2 and β *Centauri* give a relative parallax of $0''{\cdot}369$, but indicate also a large correction of the constant of aberration. Elkin's remarks have induced Moesta to publish in No. 2355–56 of the *Astron. Nachr.* explanations and corrections, and to deduce, himself, from his observations, the difference of the parallaxes $0''{\cdot}348$. Further investigations will be looked for with interest. A. M.

Mr. G. H. Darwin's Researches on the History of the Solar System.

In his previous papers, Mr. Darwin has considered the effects which tidal friction must have had upon the motions of the Earth and Moon, on the supposition that sufficient time has elapsed to allow this agency to produce its full effect. These papers were briefly noticed in the Annual Report of last year (pp. 240–243), and it was there mentioned that the Earth and Moon were traced back to a time when the day was reduced to six hours, the sidereal month to twelve hours, and the obliquity of the ecliptic to 14°. In a memoir "On the Tidal Friction of a Planet attended by several Satellites, and on the Evolution of the Solar System" recently communicated to the Royal Society, but which is not yet published, Mr. Darwin has considered the more general question of the part which tidal friction must have played in the evolution of the solar system as a whole, and of its several parts. The author concludes that the orbits of the planets round the Sun can hardly have undergone a sensible enlargement from tidal friction since these bodies attained a separate existence, and that, with regard to the sub-systems, although it is possible that the orbits of the satellites of *Mars, Jupiter* and *Saturn* about their planets may have been considerably enlarged, yet it is certainly not possible to trace the satellites back to an origin almost in contact with the present surfaces of their planets, in the same manner as was done in the case of the Moon in the paper referred to above. There are several peculiarities which distinguish the Earth and Moon from the other sub-systems, so that this result is not to be regarded as unfavourable to the hypothesis

of tidal friction. It seems to indicate, however, that some important cause of change besides tidal friction has been concerned in the evolution of the solar system, and according to the nebular hypothesis this cause would be the condensation of the heavenly bodies. The author therefore proceeds to consider the manner in which contraction and tidal friction are likely to have worked together. It is shown to be probable that solar tidal friction was a more important cause of change when the planets were less condensed than it is at present; and that if a planetary mass generates a large satellite, the planetary rotation is reduced after the change more rapidly than before, but that, nevertheless, the genesis of such a satellite is preservative of the moment of momentum which is internal to the planetary sub-system. This conclusion is illustrated by the comparatively slow rotation of the Earth, and by the large amount of angular momentum residing in the system of the Earth and Moon. The author is led, by considering the distances of the various planets from the Sun, to suggest the following cause for the observed distribution of satellites:

"According to the nebular hypothesis a planetary mass contracts, and rotates quicker as it contracts. The rapidity of the revolution causes its form to become unstable, or perhaps, as seems more probable, an equatoreal belt gradually detaches itself; it is immaterial which of these two really takes place. In either case the separation of that part of the mass, which before the change had the greatest angular momentum, permits the central portion to resume a planetary shape. The contraction and increase of rotation proceed continually until another portion is detached, and so on. There thus recur at intervals a series of epochs of instability or of abnormal change. Now, tidal friction must diminish the rate of increase of rotation due to contraction, and therefore, if tidal friction and contraction are at work together, the epochs of instability must recur more rarely than if contraction acted alone.

"If the tidal retardation is sufficiently great, the increase of rotation due to contraction will be so far counteracted as never to permit an epoch of instability to occur. Now, the rate of solar tidal friction decreases rapidly as we recede from the Sun, and therefore these considerations accord with what we observe in the solar system. For *Mercury* and *Venus* have no satellites, and there is a progressive increase in the number of satellites as we recede from the Sun.

"Whether this be the true cause of the observed distribution of satellites among the planets or not, it is remarkable that the same cause also affords an explanation of that difference between the Earth with the Moon and the other planets with their satellites, which has permitted tidal friction to be the principal agent of change with the former but not with the latter. In the case of the contracting terrestrial mass we may suppose that there was for a long time nearly a balance between the retardation due

to solar tidal friction and the acceleration due to contraction, and that it was not until the planetary mass had contracted to nearly its present dimensions that an epoch of instability could occur. If the contraction of the planetary mass be almost completed before the genesis of the satellite, tidal friction, due jointly to the satellite and the Sun, will thereafter be the great cause of change in the system, and thus the hypothesis that it is the sole cause of change will give an approximately accurate explanation of the motion of the planet and satellite at any subsequent time. It is shown in the previous papers of this series that this condition is fulfilled with the Earth and Moon."

The author considers that the series of investigations he has undertaken afford no grounds for the rejection of the nebular hypothesis, but on the contrary give evidence in favour of its main outlines, although they show that tidal friction must have introduced modifications of great, and in the case of the Earth and Moon paramount, importance.

The memoir also contains a mathematical investigation of the changes produced by tidal friction in a system consisting of a planet attended by any number of satellites revolving in circular orbits.

The Libration of the Moon.

Since Wichmann essayed to determine the Moon's physical libration from his own heliometrical measurements, more than thirty years have been allowed to elapse before further advances have been made in the practical solution of this interesting problem. Wichmann's investigation was founded upon fifty sets of observations of the crater Moesting A, referred to seven points of the Moon's illuminated limb. The discussion established the smallness of the physical libration, at least of the terms of not very long periods, and rendered it probable that their greatest effect in shifting the apparent position of a lunar spot, as seen from the earth, does not exceed two, or at the most three, seconds of arc. As this effect is, moreover, masked by the effects produced by some troublesome sources of uncertainty, it is easily understood that the real determination of the several terms of the physical libration can only be hoped for from improved methods of observation. A valuable contribution towards such a determination has now been made by Dr. E. Hartwig at Strassburg. Though the heliometer employed in the measurements is considerably smaller than the Koenigsberg heliometer, it has the advantage of some improvements in the construction of the measuring apparatus; and Hartwig has been enabled to obtain results which appear to be considerably less uncertain than those of Wichmann. The investigation is founded upon forty-two sets of observations, referring to the same crater, and

extending from November 1877 to January 1879. The deduced inclination of the lunar equator to the ecliptic is 1° 36′ 34″, with p. e. 113″·0, while Wichmann has 1° 32′ 9″, with p. e. 249″·5; so that the difference of 4′ 25″ is within probable errors. An earlier value, deduced by Kreil from observations made 1833–34 at Milan, is 1° 35′ 48″. The selenographical places of the crater agree, as was to be expected, better in latitude than in longitude. The values of the chief term of the physical libration in longitude approach sufficiently to render its fair determination probable. A renewed, or partly renewed, reduction of Wichmann's observations, and the reduction of the long series of Schlüter's observations, made 1841–44, will furnish data for investigating the terms of long periods. Since, moreover, the results of the measurements of the photographs taken at the Oxford University Observatory will be published before long, there is a prospect of some decided progress in our knowledge of the Moon's libration. A. M.

The Photometric Observations of the Harvard College Observatory.

These observations, made principally with the Equatoreal Telescope of 15-inches' aperture, during the years 1877–79, have been published in vol. xi., parts 1 and 2, of the Annals of that Observatory. In Part I., Professor Pickering commences with a description of the various forms of photometer employed, most of which, however, depend upon the combination of a double-image prism and a Nicol prism, so that two images of each of two bright objects in the same field were formed, either of which by turning the Nicol could be made as faint as desirable. Thus the faint image of the brighter object could be reduced to equality with the bright image of the fainter, and the relative brightness would be then deduced from the angle through which the Nicol is turned. On this principle the author remarks, "All of the photometers described are open to the objection that the loss of light is very great. Under the most favourable circumstances, only ·20 to ·40 of the light is used; so that with the large telescope of 15 inches' aperture, faint objects appear no brighter than with a telescope having an aperture of 7 to 9½ inches, with a common eyepiece." To meet this difficulty, photometers of different construction were used, the faint object being viewed directly with an eyepiece of the usual form, and compared with some bright object, assumed as a standard, the light of which, passing through an auxiliary telescope, was reflected into the field, and reduced by a known amount until it was no brighter than the object to be measured. The reduction of the observations with this class of photometer depends, however, upon the relative amounts of light transmitted by the large and small

telescopes. In the auxiliary telescope the light was reduced either by the introduction of a diaphragm with a minute hole in it, as in Photometer D, or the aperture was varied by a screw moving two sliding V-shaped pieces of brass, as in Photometers E, G, I, E′, and J.

In Part II., the constants of these photometers are discussed. With regard to Photometer D, the constant was determined—

1. By observation of planets through minute holes.
2. By observation of artificial stars.
3. From the light of clouds.
4. From the satellites of *Saturn*.

Considering the difficulty and the necessary uncertainty in such observations, particularly where the measurement of the aperture of a very minute hole is involved, the collected results are very accordant. The same applies to the discussion of the constants of Photometers E, G, I, and J, with this difference, that as in these latter photometers an accurate value of the constant could be obtained by computation, the author, finding that his observations were fairly accordant with the theoretical value, adopts it for reducing the observations.

Part I. gives a journal of over 5,000 observations made from August 1877 to March 1879, which comprise over 25,000 settings.

The conjunctions of the planets *Saturn* and *Mars*, and *Jupiter* and *Venus* in 1877, afforded a good opportunity for comparing their relative brightness. From 600 comparisons of *Saturn* and *Mars* made on 25 nights, and from 300 of *Jupiter* and *Venus* on 11 nights, with photometers without a telescope, the author finds—

$$\text{Albedo of } Saturn = 4{\cdot}62 \times \text{Albedo of } Mars,$$
$$\text{,, } Jupiter = 0{\cdot}86 \times \text{ ,, } Venus.$$

This is on the assumption of the mean diameter of *Mars* being $10''{\cdot}10$. If Le Verrier's value, $11''{\cdot}10$, be adopted, the result will be $5{\cdot}59 \times$ albedo of *Mars*, or if Kaiser's value of $9''{\cdot}4$ be taken, then $4{\cdot}01 \times$ albedo of *Mars*, will be the correct expression for the albedo of *Saturn*.

A series of photometric observations of all the more conspicuous double stars visible in the latitude of Cambridge, U.S., was made. The greater portion of this series was made with Photometer H, specially adapted for comparing objects very near together. The observations are given in a ledger, and the concluded results in a catalogue of 190 bright double stars. The examination of these results shows in the majority of cases such good accordance that they must carry a very high weight. Professor Pickering gives a very complete discussion of the effects of distance, position-angle, focus, and proximity of bright stars, which makes this portion of the work remarkably valuable and interesting.

Professor Pickering records an observation of the comparative brightness of *Titan*, situated very near the limb of *Saturn*, and *Rhea* following it at some distance. To the eye these satellites

appeared nearly equal, but from measurements with Photometer H, *Titan* was found to be 1·4 mag. brighter than *Rhea*. This is rather less difference than has been usually adopted.

A series of measurements was made on four nights to show what accuracy was to be expected in determining the light of a star by its limit of visibility. Four stars were selected for the purpose—α *Ursæ Minoris*, *Cephei* 51, λ *Ursæ Minoris*, and B.D. 89°, 3. The images of α *Ursæ Minoris* could not be made to disappear. Professor Pickering states that the residuals show that a variation of several magnitudes is to be expected in the observations by different persons on different days, and even when the results are rendered differential, the variations are so large that the results have little value. It is noticeable, however, that the observations of observer U, whose results were obtained on the two intermediate nights, are discordant *inter se* and with the others, whereas the results of observer P on the first and last nights are fairly accordant, and do not support the above statement.

In chapter vii., Professor Pickering discusses his investigation of the magnitudes of the satellites of *Mars*. The methods he adopted show great ingenuity in overcoming so many difficulties as naturally present themselves in determining the brightness of such minute points close to a brilliant primary. As the author states, "to measure the brightness of these satellites in terms of their primary involved the determination of a photometric interval as great as that between the Sun and Moon. The results obtained in 1877 can fortunately be compared with a second series of measurements made in 1879, which are given in an appendix; and the general conclusion arrived at is that *Deimos* is about 14·5 magnitudes fainter than *Mars*, and about 0·3 mag. fainter than *Phobos*.

An interesting discussion of the dimensions of these satellites, derived from photometric observations, is given, the equivalent diameter of the satellite being calculated on the assumption that its albedo is the same as that of *Mars*. The results on this assumption must of course be accepted with caution.

The observations of the satellites of *Jupiter*, in chapter viii., are of especial interest from the comparison of the equivalent diameters (photometrically inferred) and the diameters as actually measured. The following are the results :—

Satellite	I.	II.	III.	IV.
Light ratio	1786	2032	1271	3597
Equivalent diameter . .	0″·873	0″·818	1″·035	0″·615
Measured „ . .	1″·081	0″·910	1″·537	1″·282
Relative albedo . . .	0·652	0 809	0·453	0·230

The first line gives the ratio of the light of *Jupiter* to that of each of the satellites, the last the albedo relative to *Jupiter*. To obtain the absolute albedo for each satellite, the relative albedo

must be multiplied by the albedo of *Jupiter* (Engelmann's value 0·610). Professor Pickering's results show that Satellite I. is brighter than Satellite II.; but in this connection it is interesting to compare Mr. Common's photograph of *Jupiter* and his satellites, in which II. appears decidedly brighter than I. Professor Pickering adds that the view that the light of the satellites is variable, is not sustained by his observations.

A similarly complete discussion of the relative brightness of the satellites of *Saturn* is given in chapter ix., followed by observations of the two outer satellites of *Uranus* and the satellite of *Neptune*.

We cannot speak too highly of the energy and ability that Professor Pickering has shown in carrying out so successfully this most important photometric work—a research that redounds so very much to the honour and credit of the Harvard College Observatory. It is gratifying to know that the further photometric work referred to in the Council's Report last year is being carried forward with equal energy. We learn by Professor Pickering's recent Annual Report that the work with the Meridian Photometer of measuring all stars visible to the naked eye between the North Pole and $-30°$, has already been more than half accomplished; and it is hoped that it may all be completed by October next. The number of separate settings made is as follows:—30,076 of ordinary stars, 2,996 upper culminations, 3,168 lower culminations, 1,268 of bright stars, and 2,848 of the Pole Star; total, 40,356. The photometer, it will be remembered, consists of a transit instrument in which polarised images of the star to be measured, and of the Pole Star, are placed side by side in the field, and brought to equality by turning a Nicol prism inserted in the eyepiece. The instrument is so constructed that the two objects are viewed under precisely the same conditions, with the same magnifying power, the same aperture, the same background, and the same emergent pencil. Moreover, their positions are reversed during each observation. The observer remains in comparative darkness, and confines his attention to the settings, all the readings of the circles and the recording being done by an assistant.

We are informed that the principal want of the Observatory at the present time is means for the publication of its Annals, but we sincerely trust funds may be found available for the publication of the very important work foreshadowed above. E. B. K.

Photographic Star Spectra.

Dr. Huggins has published in greater detail than before (*Phil. Trans.* clxxi. [ii.] p. 669, 1880) his researches on the photographic spectra of stars. The stars may be divided into groups.

Some of them, including the principal white stars, give a spectrum of twelve very strong lines, probably all belonging to hydrogen. The second group gives spectra resembling that of our Sun. The third includes the red stars; the spectrum is crowded with lines which appear broader than those in the solar spectrum. The groups, however, are not well defined, and gradually fuse into each other. This is best shown by the gradual appearance of the calcium line K. As Dr. Huggins remarks, "The spectra of these stars may be arranged in a continuous series, in which first we find this line to be absent. Then it appears as an exceedingly thin line. We then pass into another stage in which it is distinct and defined at the edges; in the solar spectrum it becomes broad and winged; and, lastly, in *Arcturus*, there is further progress in the same direction, and the line, now a broad band, exceeds in intensity H." The following is the order of the stars photographed by Dr. Huggins, when arranged in the manner indicated: *Sirius*, *Vega*, *η Ursæ Majoris*, *α Virginis*, *α Aquilæ*, *Rigel*, *α Cygni*, *Capella*, *The Sun*, *Arcturus*, *Aldebaran*, *Betelgeux*. Dr. Henry Draper has also succeeded in obtaining photographs of some star spectra. A. S.

Solar Physics.

The increased number of Sun-spots observed in the last year has no doubt renewed the activity of solar physicists, but not much of the work has as yet been published. Professor Young has examined the solar spectrum under high dispersion, and paid special attention to the lines, which appear in Ångström's map to be common to two substances. Amongst 70 lines thus examined 56 have been distinctly seen double or triple.

Particular interest attaches to the lines H and K of the solar spectrum, on account of their remarkable behaviour in the spectra of stars as photographed by Dr. Huggins. These lines have hitherto been attributed to calcium, but H seems also to be coincident with a hydrogen line. Professor Young has observed in the chromosphere H to be always accompanied by a fine bright companion. This companion he at first thought to be the hydrogen line; but a remarkable prominence observed by him caused him to modify this opinion and to offer the suggestion that both H and K are due to hydrogen.

A striking spectrum of a Sun-spot was observed at Greenwich at the end of November. A number of strong lines as broad as b_1 or b_2 appeared between b and F. None of these lines are found on Ångström's or Kirchhoff's map, but under favourable circumstances faint lines coinciding with them could be seen in the ordinary solar spectrum.

Mr. Lockyer has in two papers communicated to the Royal Society his observations on the distortion of lines in Sun-spots.

Some of the lines of iron were strongly distorted, while others remained perfectly clear and straight.

Professor Tacchini continues his observations on Sun-spots and solar prominences, and is accumulating material which no doubt will ultimately prove to be of great importance.

A. S.

Captain Abney's Map of the Infra-Red End of the Solar Spectrum.

Captain Abney has published his map of the infra-red parts of the solar spectrum as photographed by him.* The spectrum could be traced in the prismatic spectrum as far as wave-length 12000 tenth-metres. It is somewhat shorter in the diffraction spectrum. The least refrangible part, however, is perfectly continuous, the last absorption line lying about 9825. There seem to be comparatively few sharp lines in this part of the spectrum, but chiefly bands. Captain Abney could not, except perhaps in one or two cases, trace any thickening of the lines when the Sun was at low altitudes; so that they do not seem to have an atmospheric origin.

A. S.

The Velocity of Light.

A careful determination of this important constant was made by Albert A. Michelson, Master U. S. Navy, in the summer of 1879, and the details of the observations have been recently published as Vol. I. Part III. of the "Astronomical Papers for the Use of the American Nautical Almanac." Mr. Michelson employed Foucault's method of a revolving mirror, with modifications in the optical arrangements which enabled him to obtain a deflection of $133^{m.m.}$, and thus to remove the objection to this method that the displacement is too small to be measured with sufficient accuracy. By using a lens of great focal length, and placing the revolving mirror 15 feet within the focus, he combined a large distance between the mirrors with a considerable radius for the deflection of the image. Thus with a collimating lens of 8 inches' diameter and 150 feet focal length a sufficiently bright image was obtained when the fixed mirror was at a distance of 2000 feet. In Foucault's experiments the greatest distance which it was found practicable to use was only 20 metres. The revolving mirror was driven by an air-turbine, actuated by an engine of 3-horse power with automatic regulator. The speed of rotation was about 257 revolutions in a second, this being measured by means of a tuning-fork, bearing on one prong a steel mirror, which reflected the light received from the revolving

* *Phil. Trans.* vol. clxxi. part 2, p. 653.

mirror to the eye, and gave a stationary image when there was exact synchronism between the vibrations of the fork and the revolutions of the mirror.

Between June 5 and July 2, 1879, 100 sets of observations, each containing ten individual measures were taken, and from these Mr. Michelson deduces, for the velocity of light, the value 299,940±51 kilometres, or 186,380 miles per second. In his estimate of the probable error he has taken into account the probable systematic errors in the measurement of the distances between the mirrors, in the determination of the speed of rotation and in the measurement of the deflection. The probable error as inferred from the casual discordance of the individual results is only 5 kilometres.

Mr. D. P. Todd has, in the *American Journal* for 1880, January, combined Mr. Michelson's determination with those of Cornu and others, giving a weight of 100 to Michelson's, 25 to Cornu's, and 1 to each of the others, and thus deduces for the most probable value of the velocity of light, 299,920 kilometres = 186,360 miles per second. Combining this with the value $498^{s}\cdot3$ for the light equation from *Jupiter's* satellites, as inferred from Glasenapp's and Delambre's determinations, he obtains for the Sun's distance 92,866,000 miles, and for the Solar parallax $8''\cdot802$. Again, taking Struve's constant of aberration $20''\cdot4451$, in combination with the value found for the velocity of light, the Sun's distance would be 92,768,000 miles, and the parallax $8''\cdot811$. Mr. Todd estimates the uncertainty in the velocity of light as 70 kilometres, that of the light equation as 1^{s}, and that of the constant of aberration as $0''\cdot025$, and thus obtains what he considers limiting values for the several quantities concerned. Combining these he obtains for the extreme values of the Solar parallax deduced from the velocity of light, $8''\cdot782$ and $8''\cdot824$, and for the final result $8''\cdot808\pm0''\cdot006$, corresponding to a mean distance of 149,345,000 kilometres = 92,800,000 miles.

Transatlantic Longitudes.

In continuation of the series of telegraphic determinations of longitudes, which have been carried out so completely in the West Indies and Central America, under the auspices of the U.S. Navy Department, Lieutenant-Commander Green and his party of American officers have fixed the longitude of the ports on the east coast of South America by means of the submarine cable from Lisbon to Pernambuco, and have thus established a most important series of secondary meridians of longitude. In particular the determination of the longitude of Buenos Ayres affords an exact starting-point for the extensive chain of meridian distances measured from Cordoba by Dr. Gould—a chain which extends from Asuncion in Paraguay on the north to Buenos

Ayres on the south, and from Colonia on the east to Santiago de Chile on the west.

The work was carried out in the years 1878 and 1879, and the results are given in detail in the Report recently published by the U.S. Navy Department. The chain of longitudes first completed was Lisbon-Madeira-Porto Grande (St. Vincent)-Pernambuco, one observer being placed alternately east and west of the other, so as to eliminate personal equation as far as possible. At Pernambuco it was found that the cable to Rio Janeiro was broken, and this section had to be deferred. Meanwhile the portion Rio Janeiro-Montevideo-Buenos Ayres, was determined, and the expedition returned to the United States. Next year (1879) the difference of longitude Greenwich-Lisbon was determined, Porthcurnow and Carcavellos (the two ends of the submarine cable) being used as transmitting or repeating stations. Subsequently the links Rio de Janeiro-Bahia, Bahia-Pernambuco, and Pará-Pernambuco were completed, and thus the whole chain of longitudes, Greenwich-Lisbon-Madeira-St. Vincent-Pernambuco-Bahia-Rio Janeiro-Monte Video-Buenos Ayres, was finished.

The importance of this determination may be estimated by the uncertainty in the previously accepted longitudes of some of the points. Thus Commander Green finds that the received longitude of Lisbon is $8^{s}\cdot54$ too small, and that the determination of the longitude of Rio de Janeiro by M. Liais is 35^{s} in error. Admiral Mouchez had, however, from a discussion of all attainable results, obtained a value for this last longitude differing only 2^{s} from that found by Commander Green.

Commander Green's determinations of longitude depend for the most part on four nights of observation, and the accordance of the separate results is satisfactory. For the observations, a combination of the transit instrument and zenith telescope with axis-view, designed by Mr. J. A. Rogers, was used, and as these instruments only weigh 125 pounds each, they were easily transported. A discordance between the clock error deduced from observations in reversed positions of the instrument, amounting to from 1^{s} to $1^{s}\cdot2$, was found to be due to flexure of the axis, and from observations of a large number of stars at various distances north and south of the zenith, the correction for flexure,

$$0^{s}\cdot55 \cos z \sec \delta,$$

was deduced.

It is to be remarked that no correction for personal equation has been applied, as it was found, by repeated use of Professor Eastman's personal-equation machine, that the habitual errors of the various observers concerned had all the same sign, and that their respective differences were very small. A small uncertainty depending on the personal equation of Lieutenant-Commander Davis with the Greenwich observers affects the longitude of the Lisbon station, and, to an equal amount, the other positions of the chain.

Professor Bredichin's Researches on the Tails of Comets.

For several years past Prof. Bredichin has been engaged on a discussion of the forms of comets' tails with reference to the hypothesis of a solar repulsive force acting on the cometary matter emitted from the nucleus, and this has now led him to the important conclusion that the tails of comets belong to three types, corresponding respectively to repulsive forces 11, 1·4 and 0·3 (the Sun's gravitating attraction being taken as 1), and composed presumably of three different sorts of matter.

Prof. Bredichin's researches are contained in the *Annales de l'Observatoire de Moscou*, vols. iii.–vii., 1877–1880, and up to the present time he has discussed the observations of the tails of 33 comets, and has calculated the values of the repulsive force $1-\mu$, under the action of which they would have been generated. For this purpose he has employed the approximate formulæ for the motion of a particle emitted from the nucleus and subject to a repulsive force from the Sun, which Bessel gave in the *Astronomische Nachrichten*, Nos. 300, 301 and 302, and which he there applied to the case of Halley's Comet in 1835. Some errors of sign in these formulæ have been corrected by M. Pape (*Astronomische Nachrichten*, No. 1173) and by Professor Bredichin (*Astronomische Nachrichten*, No. 1291). Bessel's formulæ give the co-ordinates of a particle of the tail at any time T after its emission from the nucleus (T being expressed in terms of the Gaussian unit 58·13244 days), and the expansions are carried as far as T^3. This degree of approximation is sufficient in the case of tails of the first type, for which the repulsive force is large, so that a particle takes but a comparatively short time to traverse the whole length of the tail. But with types ii. and iii. the case is different, and Bessel's formula is not sufficiently accurate for the parts of the tail at a considerable distance from the head. Thus for the comet 1874 iii. (Coggia) Prof. Bredichin found by Bessel's formulæ $1-\mu=0{\cdot}88$ near the head, and $=0{\cdot}47$ near the end of the tail, where T exceeded 0·5. He was at first led to assign a physical cause for this diminution in the repulsive force as the particle receded from the head, but he subsequently recognised that the formulæ were in fault. On using the formulæ for hyperbolic motion, given by Prof. Norton in his memoir on Donati's Comet, and subsequently rigorous formulæ deduced by Prof. Joukowsky and himself, he found that a value of $1-\mu=1{\cdot}2$ satisfied the observations of the tail throughout its whole length, and that in the case of the Comet 1860 iii., the value of $1-\mu$ should be 1·36 instead of 0·64, as found by Bessel's formulæ. To estimate the effect of the error in Bessel's approximate formulæ, Prof. Bredichin has taken a comet with perihelion distance 0·5 (being the arithmetic mean of the perihelion distances of all observed comets), and constructs the tails of the three types, taking

$1-\mu$=11·0, 1·4 and 0·3 respectively, and with the rigorous formulæ, computing the co-ordinates for values of t up to 30 days. With these co-ordinates he then finds the values given for $1-\mu$ by Bessel's formulæ at different distances from the head.

The results of Prof. Bredichin's calculations are summarised in a table, giving the types to which the tails of 28 comets belong, together with approximate elements of their orbits (*Annales de l'Observatoire de Moscou*, vol. vi. Part I. p. 58). Adding to these five comets, viz., those of 1682, 1680, 1769, 1744, 1843 and 1880, discussed in a subsequent memoir (*Annales*, vol. vii. Part I.), there are in all 34 comets classified, with 17 tails belonging to type i., 17 to type ii., and 13 to type iii. Several of the comets have two tails, belonging, of course, to different types. The comet of 1744 is remarkable for the five tails seen by Chesèaux and Delisle six days after the perihelion passage. For these Prof. Bredichin finds values of $1-\mu$ ranging from 1·0 to 2·4, and he explains this divergence of the tails by supposing that near perihelion the varieties in the substances of the same type would show themselves. The tail of Donati's Comet, type ii., which near perihelion was decomposed into several juxtaposed conoids, presented an analogous case. The tail of the Comet of 1744 before perihelion was of type i.

For his three types Prof. Bredichin adopts:—

Type i.	$1-\mu = 11\,0$	$g = 0{\cdot}15$	or 4500 metres per 1ˢ.
ii.	$1-\mu = 1\,3$ or 1·4	$g = 0{\cdot}03$	or 900 „ „
iii.	$1-\mu = 0{\cdot}2$ or 0·3	$g = 0{\cdot}01 \pm$	or 300 „ „

$1-\mu$ being the solar repulsive force, and g the velocity of emission of the particles, deduced from the observed dimensions of the head.

Considering that these three types represent different substances, and adopting Zöllner's hypothesis of a repulsive force due to electricity and inversely proportional to the specific gravity, Professor Bredichin infers that the tails of the three types are composed respectively of hydrogen, carbon, and iron. Other elements of nearly the same atomic weight may replace or be mixed with the carbon or iron of the second or third types, and thus the tail may be spread out in the plane of the orbit, as in the case of Donati's Comet. But the first type of tail composed of hydrogen will always remain separated from the others. As a support to this hypothesis, Professor Bredichin points out that the velocities of emission for the three types are of the order of molecular velocities of gases, though they are somewhat larger in magnitude (*Annales*, vol. v., Part II., p. 137; vol. vi., Part I, p. 59).

Papers read before the Society from February 1880 *to February* 1881.

1880.

Mar. 12. Phenomena of *Jupiter's* Satellites, observed at Mr. E. Crossley's observatory, Bermerside, Halifax. J. Gledhill.

Observations of the Satellites of *Mars*. Prof. Asaph Hall.

Supplementary note on the changes in the error of Hansen's Lunar Tables. W. T. Lynn.

Observations of *Mimas* and of an Occultation of *Rhea*, in 1879, with the 26-in. equatoreal of the United States Naval Observatory, Washington. Prof. E. S. Holden.

Disappearance of *Jupiter's* Satellites in 1883. Rev. S. J. Johnson.

An examination of the double-star measures of the Bedford Catalogue. S. W. Burnham.

Mean heliographic latitude of Sun-spots for the years 1874 to 1879, deduced from the photographs taken at the Royal Observatory, Greenwich. Astronomer Royal.

Observations of the great southern Comet 1880, from Feb. 2 to Feb. 9, made at the Cape of Good Hope. D. Gill.

Observations of the great southern Comet 1880, from Feb. 1 to Feb. 7, made at Monte Video. Rev. S. S. O. Morris.

Observations of the exterior Satellite of *Mars* at the Oxford University Observatory. Prof. C. Pritchard.

On the longitude of the Observatory, Windsor, New South Wales. J. Tebbutt.

On some changes in the markings of *Mars*. N. E. Green.

Note on Mr. Maxwell Hall's paper on the Nebula in the *Pleiades*. C. Wolf.

Note on the spectrum of Mr. Baxendell's new Star in *Canis Minor*. Dr. H. C. Vogel.

Note on the phenomenon known as "Shadow Bands." Dr. R. Copeland.

On the determination of the personal equation of Lunar Observers. E. Neison.

Description of a proposed new uniform pressure Clock. T. Buckney.

Note on the photographic diameter of the Moon. E. Neison.

Observations of the great southern Comet made at Monte Video. Lieut. B. Gwynne.

Account of observations of the total Solar Eclipse of 1878, July 29, made at Denver, Colorado. A. C. Ranyard.

Apr. 9. Note on a precessional Globe. R. H. M. Bosanquet.

Observations of the great southern Comet, 1880, made at the Melbourne Observatory. R. L. J. Ellery.

Observations of the great southern Comet, 1880, made at the Observatory, Sydney. H. C. Russell.

On mean Refractions. E. J. Stone.

410 radiants of Shooting Stars, deduced from observations in Hungary in the years 1871 to 1878, and 80 probable radiants deduced from the 410 radiants. Dr. N. de Konkoly.

On the relative star magnitude of *Mars* in February and March 1880. Lord Lindsay.

On the theoretical value of the acceleration of the Moon's mean motion in longitude produced by the change of eccentricity of the Earth's orbit. Astronomer Royal.

The Nebula in the *Pleiades*. A. A. Common.

Observations of Meteors, July 1879 to March 1880. D. W. Barker.

Rotation period of *Jupiter*. T. D. Brewin.

May 14. On the variability of B. A. C. 2472. J. Tebbutt.

On the longitude of the Observatory, Windsor, New South Wales (supplement). J. Tebbutt.

Notice of the great southern Comet. J. Tebbutt.

Observations of the great southern Comet, 1880. D. W. Barker.

On a photograph of *Jupiter's* spectrum, showing evidence of intrinsic light from that planet. Dr. H. Draper.

On a mechanical attachment for equatoreal mountings to facilitate sweeping in right ascension. D. P. Todd.

Central Solar Eclipses in Great Britain during 1000 years. Rev. S. J. Johnson.

Elements of Schäberle's Comet. J. R. Hind.

The possible ten-month period of variation in latitude. A. M. W. Downing.

Ephemeris for physical observations of *Jupiter*, 1880–81. A. Marth.

On the preparations to be made for observations of the Transit of *Venus*, 1882, Dec. 6. Astronomer Royal.

On the determination of the Solar Parallax by the parallactic inequality in the motion of the Moon. J. Campbell and E. Neison.

Note on the Astronomer Royal's investigation of the theoretical value of the acceleration of the Moon's mean motion. Prof. J. C. Adams.

Investigation of the secular acceleration of the Moon's mean motion, caused by the secular change in the eccentricity of the Earth's Orbit, taking into account terms of the order m^4, but neglecting the eccentricity and inclination of the Moon's Orbit. Prof. J. C. Adams.

Observations of Comet, 1880 b (Schäberle), made at Dun Echt, with the filar micrometer of the 15-inch refractor. Lord Lindsay.

June 11. On a simple method of finding a Meridian Line. Major-Gen. J. Baillie.

On a partially graphic method of computing Solar Eclipses and Occultations of the Moon. Rev. J. Pearson.

Ephemeris for finding the positions of the Satellite of *Neptune*. A. Marth.

Coincidences of Sun-spots and Auroræ in the olden time. Rev. S. J. Johnson.

On the Star No. 804 in the first Greenwich Seven-Year Catalogue. A. Wagner.

The Babylonian Astronomy. Part iii. R. H. M. Bosanquet and Prof. A. H. Sayce.

On the determination of the Solar Parallax from Heliometer Observations of *Mars*, made at Ascension during the opposition of 1877. D. Gill.

On the first results of the researches in connection with the lunar physical libration. Prof. C. Pritchard.

Addition to the Ephemeris for the physical observations of *Jupiter*. A. Marth.

Note on the Nebula near *Merope* (extract from a letter to the Foreign Secretary). W. Tempel.

On the refractive and dispersive powers of various samples of glass. G. L. Lohse.

Note on the constant of lunar parallax. Prof. J. C. Adams.

Addition to a paper entitled "On the theoretical value of the acceleration of the Moon's mean motion in longitude, produced by change of eccentricity of the Earth's Orbit." Sir G. B. Airy.

On the construction of a new form of Micrometer. Prof. C. Pritchard.

On an inexpensive form of Chronograph. Prof. C. Pritchard.

On a method of determining the pressure on the Solar Surface. Prof. E. Wiedemann.

Nov. 12. Elements of Comet Schäberle (1880 ii.). Prof. T. H. Safford.

Southern double stars. H. C. Russell.

Comparison of the observations of the Sun, made at Washington 1866–75, with Hansen's Tables. Dr. C. R. Powalky.

Third Catalogue of micrometrical measures of double stars, made at the Temple Observatory, Rugby. G. M. Seabroke.

The discovery of κ *Pegasi* as a close double star. S. W. Burnham.

The August Perseids. Admiral Sir E. Ommanney.

On the method of least squares. J. W. L. Glaisher.

On the possible performance of an object glass for stargazing. E. Sang.

Observations of Comet I. 1880, made at the Royal Observatory, Cape of Good Hope. D. Gill.

The July Aquariads, 1880. E. F. Sawyer.

Observations of a meteor. Nov. 4th, 1880. C. F. Varley.

A new Nebula. J. Baxendell.

On the annual parallax of the Star P. III. 242. Prof. R. S. Ball.

On the Spectrum of Comet 1880 d. (Hartwig). W. H. M. Christie.

Saturn in October 1880. W. F. Denning.

Note on Hansen's value of the semi-diameter of the Moon. E. Neison.

The motions and varieties of the Jovian Spots. W. F. Denning.

Observations of Ceraski's variable star in *Cepheus*. G. Knott.

Addition to a paper on the method of least squares. J. W. L. Glaisher.

On a new form of "Ghost" Micrometer. C. E. Burton and H. Grubb.

Note on a Photograph of *Jupiter*. A. A. Common.

Note on the Nebulæ near *Merope*. A. A. Common.

Particulars of the mounting of a 3-foot Reflector. A. A. Common.

A determination of the diameter of *Mars* at the mean distance of the Earth from the Sun. A. M. W. Downing.

Cometary observations made at the University Observatory, Oxford. Prof. C. Pritchard.

Observations of the red spot on *Jupiter*. A. V. Nursinga Row.

Note on a phenomenon of *Jupiter's* Satellites. Capt. W. Noble.

On the determination of the coefficient of the parallactic inequality in the expression for the Moon's Longitude. E. J. Stone.

Telegraphic determination of the longitude of Shanghai. Dr. L. S. Little.

Dec. 10. Note on the length of the Pendulum observed by De L'Isle de la Croyère at Archangel, in 1728. Major J. Herschel.

Observations of the great southern Comet, I. 1880, made at Castlemaine, Victoria. Dr. W. Bone.

On the spectrum of a Sun-spot observed at the Royal Observatory, Greenwich. Astronomer Royal.

Ephemeris for finding the positions of the Satellites of *Uranus*, 1881. A. Marth.

Observations of Meteors, Nov. 25–28, 1880. W. F. Denning.

The Meteors of Nov. 14, 1880, observed at Moncalieri. Signor F. Denza.

1881. Note with respect to the rate of motion of gaseous matter projected from the Sun. A. C. Ranyard.

Jan. 14. Further researches on the annual parallax of 61 *Cygni*. Prof. R. S. Ball.

The binary Star *β Delphini*. S. W. Burnham.

Occultation of Stars by the Moon, seen at the Stonyhurst Observatory. Rev. S. J. Perry.

Observations of *Jupiter's* Satellites, made at the Stonyhurst Observatory. Rev. S. J. Perry.

Further notes on the Nebula in the *Pleiades*. Maxwell Hall.

The partial Eclipse of the Sun, Dec. 31, 1880. J. Rand Capron.

Observations of the Solar Eclipse, 1880, Dec. 31, made at the University Observatory, Strassburg. Prof. A. Winnecke.

On Mr. Stone's alterations of Bessel's Refractions. W. H. M. Christie.

Spectroscopic results for the motions of Stars in the line of sight, obtained at the Royal Observatory, Greenwich, IV. Astronomer Royal.

Observations of occultations of Stars by the Moon, of phenomena of *Jupiter's* Satellites, and of the Eclipse of the Sun, 1880, Dec. 31, made at the Royal Observatory, Greenwich. Astronomer Royal.

Remarks on Dr. Hartwig's recent determination of the lunar physical libration. Prof. C. Pritchard.

Eclipse of the Sun, Dec. 31, 1880, observed at the University Observatory, Oxford. Prof. C. Pritchard.

On the apparent conjunctions of the Satellites of *Uranus*, 1881. A. Marth.

On the North Polar distances of the Cape Catalogue for 1840. A. M. W. Downing.

Notes on Dr. H. Draper's photograph of the Nebula in *Orion*. A. C. Ranyard.

Description of an observing seat for an Equatoreal. Prof. G. W. Hough.

Note on the Nebula in the *Pleiades*. H. Pratt.

On some difficulties connected with the determination of the diameter of *Mars*. E. J. Stone.

The Solar Eclipse of 1880, Dec. 31, observed at the Radcliffe Observatory, Oxford. E. J. Stone.

On the bearing of ancient Eclipses, and especially that of Agathocles, on the Moon's motion. Prof. J. Celoria.

List of Public Institutions and of Persons who have contributed to the Library, &c., since the last Anniversary.

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Prague Observatory.
Rome, Central Meteorological Office.
Rome, Italian Spectroscopic Society.
Rome, Pontifical Academy dei Lincei.

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ADDRESS

Delivered by the President on Presenting the Gold Medal of the Society to Professor Axel Möller.

GENTLEMEN,—

It now becomes my duty to put before you the main points in the investigations of Professor Axel Möller on the motion of Faye's Comet, for which your Council have this year awarded him the Gold Medal of the Society, and this I shall endeavour to do in as succinct a manner as possible.

The comet which forms the subject of the investigations for which the Medal has been awarded was discovered by M. Faye at the Observatory of Paris on November 22, 1843, about five weeks after its perihelion passage. Notwithstanding this, the impossibility of representing its motion by parabolic elements was soon evident, and the limited extent of the orbit being indicated a few weeks after discovery, the attention of observers was specially directed to the comet, and observations were made as late as April 10, 1844, by M. O. Struve with the Pulkowa refractor. A pretty complete determination of the orbit from the observations of 1843–44 was made by Le Verrier, who also calculated the perturbations during the ensuing revolution due to the action of *Venus*, the Earth, *Mars*, *Jupiter*, and *Saturn*, and thus obtained the elements corresponding to the next perihelion passage on April 3, 1851. At that time Professor Challis was giving close attention to the observation of comets by means of the Northumberland Equatoreal at Cambridge, and with the aid of the Ephemeris founded upon Le Verrier's elements he succeeded in observing Faye's Comet as early as November 28, 1850, continuing his observations until March 4, or nearly a month after it was seen elsewhere. Observations at this second appearance were confined to the Cambridge Observatory, and the Observatories at Pulkowa, and Harvard College, U.S. Le Verrier issued an Ephemeris corrected by the earlier observations at Cambridge, but did not further continue his calculations.

It does not appear that any computations bearing upon the return of the comet in 1858 were made, beyond an approximate Ephemeris circulated from the *Nautical Almanac* office. With the aid of this Ephemeris the comet was detected by Dr. Bruhns with the Berlin Refractor on September 7, and observations were continued till October 16.

Early in 1859 the Society of Natural Sciences at Dantzic

offered a prize for the determination of the orbit of Faye's Comet from the three appearances of 1843–44, 1850–51, and 1858, the memoirs to be sent in at the beginning of January, 1861. I am not aware if it was this circumstance which directed Professor Möller's attention to the comet, but it was at this period that his investigation of its motion was commenced. His first paper appeared in No. 1259 of the *Astronomische Nachrichten*, and is dated from Lund in April 1860. Adopting the elements which Le Verrier had brought forward to 1851, he compares them with the series of Cambridge observations, commencing on December 25, 1850, and forming normal places, he obtains corrected elements for 1843. From this amended orbit he calculates the perturbations of *Venus*, the Earth, *Mars*, *Jupiter*, *Saturn*, and *Uranus*, for the intervals over which the comet was observed in 1843–44 and 1850–51, and then makes a comparison with the observations at both appearances. Normal places are again formed and the orbit is further corrected. Thus pretty accurate elements are derived for 1843 November 9, and 1851 February 20, which form the definite results of Professor Möller's first communication.

In No. 1295 of the same periodical he brings the observations made in 1858 to bear upon the orbit, having first calculated the perturbations during the comet's visibility as before, and introduces Encke's hypothesis of a resisting medium, the existence of which had been rendered so probable from the researches made by that astronomer on the motion of the comet which bears his name. He considered that the calculations detailed in this second memoir (involving, it will be seen, three appearances of the comet) proved that an hypothesis was needed to explain the motion of Faye's Comet, and that one of the character advocated by Encke would be nearly correct. This conclusion naturally attracted the attention of astronomers, because Faye's Comet at no time approaches the Sun within the Earth's mean distance, and the effect of a resisting medium could hardly have been expected to have been appreciable upon the comet's motion. This question is further examined by Professor Möller in No. 1314 of the *Astronomische Nachrichten*, with reference to a communication made by Baron Plana to the Turin Academy, and again in No. 1317, with respect to the hypothesis of Valz on the density of the ether.

In No. 1358, Professor Möller has some further researches on the orbit of the comet from the observations at the first three returns, in which additional refinement is introduced in the computation of the planetary perturbations, and a close representation of the observations is produced, the orbit for 1858 being considered not only exact enough for prediction at the ensuing return to perihelion, but for connecting with accuracy the observations that might be then made, with the earlier ones. In his next communication to the *Astronomische Nachrichten*, with reference to Faye's Comet (No. 1522), he made an announcement

which is of especial interest, as according with the preconceived ideas of astronomers on the improbability of resistance to the motion of the comet from the etherial medium: he there states distinctly that he had given up the idea of action from this cause, and had satisfied himself that the observations at the first three appearances were perfectly accordant, without any hypothesis whatever. This conclusion, it must be observed, had not been arrived at without the introduction of one refinement after another, and wading through a very heavy mass of computations of a difficult and laborious character. In the same memoir, slight corrections are again applied to the elements in 1843–44, 1850–51, and 1858, and the orbit of the latter year is carried forward to the ensuing return in the autumn of 1865, by the calculation of the planetary perturbations in the interval; Professor Möller also supplied an accurate Ephemeris from July 1 to November 22. This memoir, in which precise prediction of Faye's Comet was first made, is dated from Lund, in March 1865. The comet was detected by D'Arrest, with the Copenhagen Refractor, on August 22, and, in publishing his first observation, he wrote, "The agreement with Professor Möller's calculations, after the seven years' invisibility of the comet, is extraordinary, in fact almost complete," the difference being only $1^{s}\cdot7$ in Right Ascension and $4''$ in Declination: notwithstanding the refinement introduced into Professor Möller's work, probably no one had anticipated so admirable a confirmation of the skill and labour with which it had been conducted. In the *Astronomische Nachrichten*, No. 1548, Professor Möller continued his accurate Ephemeris to April 14, 1866.

Resuming his investigations in 1870, he found that when the observations of 1865–66 were brought to bear upon them, in addition to those at the three previous returns, the agreement between calculation and observation was not so satisfactory as before. He accordingly did not shrink from a complete revision of the computation of perturbations, aiming at the utmost attainable accuracy: the normal positions were thoroughly examined, improved places of some of the comparison stars introduced, and, in treating the equations of condition, a term was included for the correction of the mass of *Jupiter* deduced by Bessel from the elongations of his satellites, which had been adopted through the whole of Professor Möller's work. Thus the most precise orbit it was possible to determine for 1865, as the ground-work for further computation, was obtained. The value of *Jupiter's* mass indicated by these laborious researches on the motion of Faye's Comet was found to be $\frac{1}{1047\cdot788}$, that assigned by Bessel being $\frac{1}{1047\cdot879}$, these values agreeing within their probable errors. Details of these additional computations will be found in *V. J. S.*, vol. vii.

The perturbations during the ensuing revolution were calcu-

lated with all strictness, and elements assigned for the epoch of the comet's return to perihelion in 1873. Its track in the heavens in that year was unfavourable for observation, and only four positions were secured between September 3 and December 23. By the Marseilles observation on the former date, Professor Möller's predicted place was less than six seconds of arc from the true one, a really marvellous confirmation of the accuracy with which his investigations of the comet's motion during forty years had been conducted.

Once more he determined the effect of perturbation during a whole revolution, with the same refinement as previously, and in September 1878 communicated to the Academy of Sciences at Stockholm elements and an accurate Ephemeris for the actual appearance of 1880–81, and, as we have just seen, with renewed success, though the effect of planetary attraction in this interval has been greater than in any other revolution since the comet was discovered.

Not content with following the comet through each successive revolution from 1843, Professor Möller, in a paper presented to the Academy of Stockholm in January 1873, computes the perturbations backward to December 25, 1838, and ascertains the effect of a pretty near approach to *Jupiter* in March 1841, when the distance of the comet from the planet was less than two-thirds of the Earth's mean distance from the Sun: thus the perturbations have been rigorously calculated by Professor Möller from December 25, 1838, to January 13, 1881. In the same paper he also examines the circumstances of a much nearer approach near the passage of the ascending-node in 1816, and infers a minimum distance of about 0·3.

It is necessary to bear in mind that the class of computation involved in Professor Axel Möller's investigations is, so to say, of a high order, and does not admit, as is often the case with heavy masses of astronomical calculations, of being set out for the ordinary computer. Considerable mathematical knowledge, and knowledge of refined methods, and of their adaptability to particular cases is absolutely essential; and Professor Möller's success has proved that he possesses this knowledge in an eminent degree. I believe that you will consider that your Council has been fully justified in awarding to Professor Möller the highest mark of approval and respect which the Royal Astronomical Society has it in its power to bestow, and I further entertain the belief that this award will give satisfaction to astronomers in all countries, as encouraging a very monotonous and tedious, but not less important, branch of astronomical research.

The President then, delivering the Medal to the Foreign Secretary, the Earl of Crawford and Balcarres, addressed him in the following terms:—

In transmitting our Gold Medal to Professor Axel Möller, I ask you, my Lord Crawford, to assure him of the great interest

which the Royal Astronomical Society has taken in his researches on the motion of Faye's Comet during the long period over which they have extended, and to convey to him the best wishes of the Society that health and energy may be spared him to continue these researches, which have been attended with such admirable and well-merited success.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected :—

President.

J. R. Hind, Esq., F.R.S., Superintendent of the *Nautical Almanac.*

Vice-Presidents.

Arthur Cayley, Esq., M.A., LL.D., D.C.L., F.R.S., Sadlerian Professor of Pure Mathematics, Cambridge.
Edwin Dunkin, Esq., F.R.S.
William Huggins, Esq., LL.D., D.C.L., F.R.S.
E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.

Treasurer.

Francis Barrow, Esq., M.A.

Secretaries.

W. H. M. Christie, Esq., M.A.
J. W. L. Glaisher, Esq., M.A., F.R.S.

Foreign Secretary.

The Earl of Crawford and Balcarres, F.R.S.

Council.

J. C. Adams, Esq., M.A., LL.D., F.R.S., Lowndean Professor of Astronomy, Cambridge.
Sir G. B. Airy, K.C.B., M.A., LL.D., D.C.L., F.R.S., Astronomer Royal.
James Campbell, Esq.
A. A. Common, Esq.
G. H. Darwin, Esq., M.A., F.R.S.
Major J. Herschel, R.E., F.R.S.
E. B. Knobel, Esq.
George Knott, Esq., LL.B.
Albert Marth, Esq.
Edmund Neison, Esq.
A. Cowper Ranyard, Esq., M.A.
H. J. S. Smith, Esq., M.A., LL.D., F.R.S., Savilian Professor of Geometry, Oxford.

ERRATUM.

In the *Monthly Notices*, vol. xli. p. 142—Last Contact with De La Rue reflector—*for* $3^h\,38^m\,2^s{\cdot}0$ *read* $3^h\,28^m\,2^s{\cdot}0$.